NEBOSH Certificate
Unit GC2 (International)
Controlling Workplace Hazards

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The Course Team

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NEBOSH INTERNATIONAL GENERAL CERTIFICATE

UNIT GC2: CONTROLLING WORKPLACE HAZARDS

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Introduction

COURSE STRUCTURE

This textbook has been designed to provide the reader with the core knowledge needed to successfully complete the NEBOSH International General Certificate in Occupational Health and Safety, as well as providing a useful overview of health and safety management. It follows the structure and content of the NEBOSH syllabus.

The NEBOSH International General Certificate consists of three units of study. When you successfully complete any of the units you will receive a Unit Certificate but to achieve a complete NEBOSH International Certificate qualification you need to pass the three units within a five-year period. For more detailed information about how the syllabus is structured, visit the NEBOSH website (www.nebosh.org.uk).

Unit IGC1: Management of International Health and Safety	
Element 1	Foundations in Health and Safety
Element 2	Health and Safety Management Systems 1 - Policy
Element 3	Health and Safety Management Systems 2 - Organising
Element 4	Health and Safety Management Systems 3 - Planning
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Unit GC2: Controlling Workplace Hazards	
Element 1	Workplace Hazards and Risk Control
Element 2	Transport Hazards and Risk Control
Element 3	Musculoskeletal Hazards and Risk Control
Element 4	Work Equipment Hazards and Risk Control
Element 5	Electrical Safety
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	Revision and Examination Preparation

Unit GC3: Health and Safety Practical Application
Aim of the Practical Assessment
Workplace Inspection
Report to Management

Assessment

To complete the qualification, you need to pass two formal written exams (one for Unit IGC1 and one for Unit GC2), as well as a safety inspection of your workplace, including a short report to management (Unit GC3).

Each written exam is two hours long and consists of one long question (20% of the marks) and ten short questions (each being 8% of the total marks). You must answer all questions.

To help you prepare, this textbook contains Exam Skills activities at the end of each element of your course. Guidance on how to answer an exam-style question is provided, and suggested answers are provided in a section at the end for you to compare them with your own.

We have also included some guidance on how to go about completing the safety inspection of your workplace so you will be fully prepared for that, too.

More Information

As you work your way through this book, always remember to relate your own experiences in the workplace to the topics you study. An appreciation of the practical application and significance of health and safety will help you understand the topics.

Keeping Yourself Up to Date

The field of health and safety is constantly evolving and, as such, it will be necessary for you to keep up to date with changing legislation and best practice.

RRC International publishes updates to all its course materials via a quarterly e-newsletter (issued in February, May, August and September), which alerts students to key changes in legislation, best practice and other information pertinent to current courses,

Please visit http://www.rrc.co.uk/news/newsletters.aspx to access these updates.

Other Textbooks Available in this Series

- The Management of International Oil and Gas Health and Safety: A Guide to the NEBOSH International Technical Certificate in Oil and Gas Operational Safety (First Edition, June 2012)
- NEBOSH Award in Health and Safety at Work – ARABIC (First Edition, June 2012)

RRC International is continually adding to its range of textbooks. Visit www.rrc.co.uk/publishing for a full range of current titles.

User Guide

Before you start to use this textbook, take a moment to read this User Guide.

At the start of each element you will find a Contents table and a list of Learning Outcomes. These are important because they give you an idea of the different topics you will be studying and what you are aiming to achieve.

KEY INFORMATION

Each main section of material starts with a Key Information box. This box presents an overview of the important facts, ideas and principles dealt with under the section heading. There is no depth or detail here, just the basics.

After the Key Information box comes the main content. The main content has been designed to explain and describe the topics specified in the relevant section of the syllabus to the expected level. Examples have been given to illustrate various ideas and principles in a variety of different workplaces.

TOPIC FOCUS

Topic Focus boxes provide depth and detail by concentrating on a very specific topic area.

GLOSSARY

Glossary boxes contain descriptions or definitions of words or phrases that are included in the main content.

HINTS AND TIPS

Hints and Tips boxes contain simple ideas that can help you as you work through the materials and prepare for the end-of-course exam.

MORE...

More... boxes contain sources of further information. (Websites are current at the time of writing.) Although this book includes everything you need, it is worth looking at these additional sources if you can. This will give you a broader and deeper understanding.

EXAM SKILLS

After each element you will find a short Exam Skills section containing an exam-style question (or two) for you to practise answering. Guidance on how to answer is provided, together with a Suggested Answer for you to compare with your own.

REVISION QUESTIONS

At the end of each section you will find Revision Questions. These are not past exam questions, but should be useful for self-assessment.

You can mark your answers against the Suggested Answers provided.

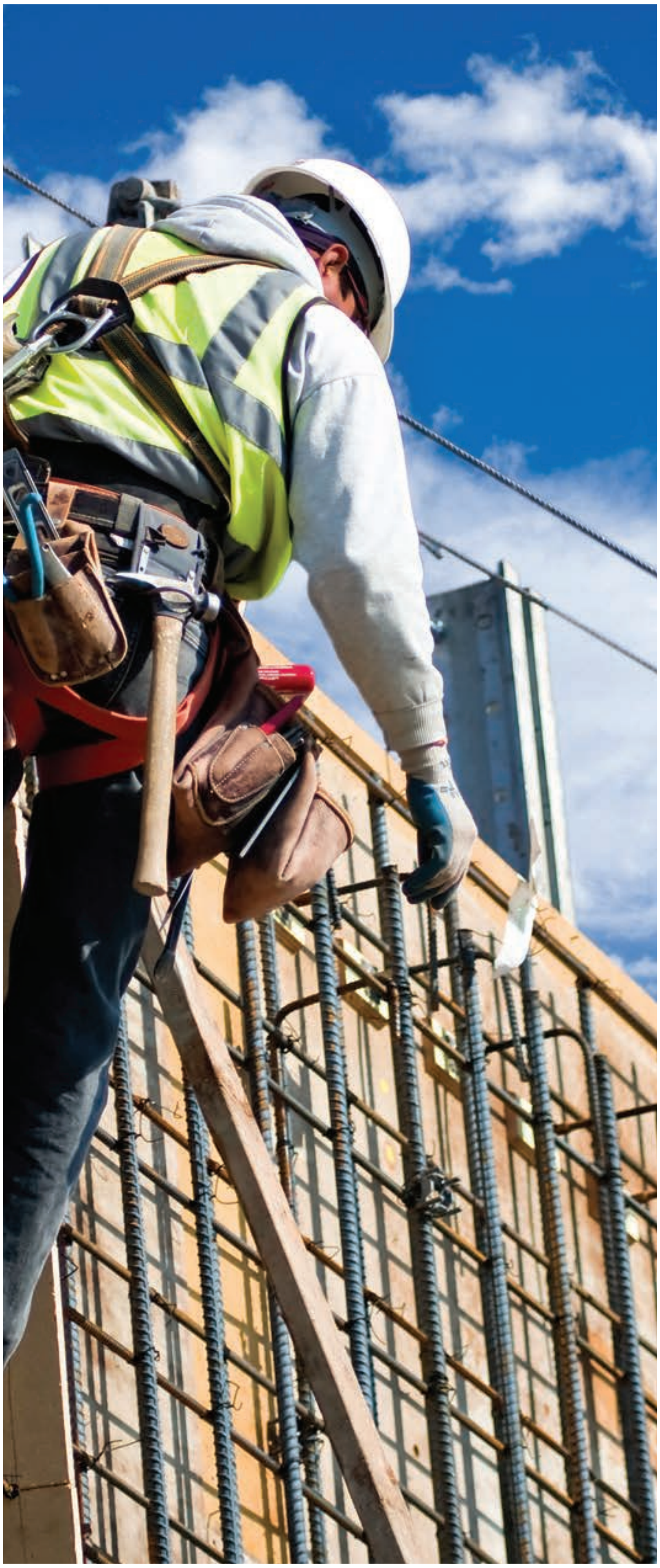
Summary

Each element finishes with a Summary. This presents a very concise reflection of the key ideas and principles contained in the element. When you have finished studying an element you might use the summary to test your recall of the detailed information contained within the element.

When you have studied all of the elements in a unit you should move on to look at the Revision and Examination Guide.

WORKPLACE HAZARDS AND RISK CONTROL

ELEMENT 1



LEARNING OUTCOMES

On completion of this element, you should be able to demonstrate understanding of the content by applying what you have learnt to familiar and unfamiliar situations. In particular, you should be able to:

1. Outline common health, welfare and work environment requirements in the workplace.
2. Explain the risk factors and appropriate controls for violence at work.
3. Explain the effects of substance misuse on health and safety at work and control measures to reduce such risks.
4. Explain the hazards and control measures for the safe movement of people in the workplace.
5. Explain the hazards and control measures for safe working at height.
6. Identify the hazards and control measures for temporary works.

Contents

Health, Welfare and Work Environment Requirements

KEY INFORMATION

- Minimum welfare provision means ensuring that workers have access to drinking water, washing facilities, toilet facilities, accommodation for clothing, rest and eating facilities, seating, ventilation, heating and lighting.
- Working in extreme temperatures can cause health effects such as dehydration, heat stress and heat stroke in hot environments, and hypothermia and frostbite in cold environments. These ill-health effects can be managed by controlling the environment and providing facilities, PPE, training and frequent breaks.
- Falling materials can cause injury, and can be prevented by safe stacking of products and materials and safe storage.

HEALTH, WELFARE AND ENVIRONMENT

Here we outline good practice with regard to basic welfare requirements that apply to workplaces. Statute law and codes of practice will normally dictate exact local standards. (Note that although first aid is often considered to be part of an employer's welfare provision, this topic has already been covered in Unit IGC1.)

TOPIC FOCUS

Work Environment Requirements

The workplace environment should be designed and regulated as far as is possible to ensure safety and freedom from health risk. This is often not possible for outdoor workplaces, or at least only possible to a limited extent. For indoor workplaces, some basic environment standards are:

- **Space** – provision of adequate space to allow workers to perform the task safely.
- **Seating** – provision of appropriate seating where work tasks allow. Seats should be stable, with a backrest and footrest, where appropriate.
- **Ventilation** – provision of a sufficient supply of fresh or purified air.
- **Heating** – maintenance of a reasonable temperature in the workplace. Note that workers carrying out hard manual work will prefer a cooler workplace than those doing sedentary work.
- **Lighting** – provision of adequate lighting.
- **Noise** – provision of controls to reduce excessive noise, if necessary.

Workers should have access to drinking water

Minimum Welfare Standards

Minimum welfare standards include provision of:

- **Drinking water** – access to clean drinking water. If non-potable water is also available then supplies should be clearly labelled to distinguish between the two.
- **Toilet facilities** – access to a sufficient number of toilets (WCs) for the number of workers present, with separate facilities for men and women. They should be protected from the weather and adequately clean, lit and ventilated. Special provision should be made for the disabled.
- **Washing facilities** – access to suitable washing facilities by toilets, changing facilities and as required in work areas. Showers may be necessary if the work is dirty, strenuous, or involves potential contamination with hazardous substances. Washing facilities should have hot and cold (or warm) running water, soap and towels (or other means of drying).
- **Changing rooms** – suitable changing facilities if workers have to change into special work wear and this involves significant undressing. These should be clean, adequately lit and ventilated, with separate facilities for men and women.
- **Accommodation for clothing** – lockers or other storage facilities where workers have to change for work so that their personal clothing can be kept clean and secure. Separate storage for dirty work clothing may be necessary to prevent cross-contamination.

- **Resting and eating facilities** – access to suitable rest areas where workers can take a break from work. Such areas should have sufficient seating and be away from hazardous work areas, allowing workers to remove PPE and relax. Eating facilities should be provided so that food can be eaten in a hygienic environment. If hot food is not provided at work, then basic facilities might be provided so workers can make their own hot drinks and food. Non-smoking facilities should be available to protect workers from second-hand smoke. (Note that smoking in workplaces is tightly regulated by statute law in many countries.)

Factors to consider when providing **workplace lighting**:

- Minimum light levels (lux levels) should be achieved; these are normally indicated by local code of practice or guidance.
- Natural light should be used in preference to artificial light.
- Light levels should be adjusted to suit the level of detail required and the visual acuity of the workers.
- Local lighting, such as spotlights positioned above machinery, might be required to give higher levels of light on critical areas.
- Lighting must be arranged to avoid reflections and glare that might dazzle or temporarily disable workers.
- Lighting must be arranged to avoid the creation of shadows that might obscure areas and create risk.
- Flickering should be avoided to prevent nuisance and in particular the "stroboscope effect" (see machinery lighting in Element 4).
- Lighting must be suitable for the environment (e.g. intrinsically safe lighting used in a flammable atmosphere).
- Emergency lighting should be provided to ensure safety in the event of mains supply failure.

EXPOSURE TO EXTREMES OF TEMPERATURE

Effects of Exposure

Extreme temperature environments can be found in some workplaces. For example, workers in a foundry or bakery will be exposed to a very hot, dry environment; workers in a cold storage warehouse will be exposed to a very cold environment. Those who work outdoors may be exposed to both extremes depending on climate and season.

Health and safety effects of working in a **hot environment**:

- Dehydration – water is lost as a result of sweating.
- Muscle cramps – as a result of salt loss through sweating.
- Heat stress – where core temperature (37°C) cannot be controlled and starts to increase; causes discomfort, lethargy, headaches and fainting.
- Heat exhaustion – a precursor to heat stroke.
- Heat stroke – where core temperature increases rapidly; causes hallucinations, coma and death.
- Other effects associated with the source of the heat, such as skin burns or cancer from exposure to sunlight, or burns from radiant heat and contact with hot surfaces.

Health and safety effects of working in a **cold environment**:

- Hypothermia – core temperature drops below 35°C; causes shivering, mood swings, irrational behaviour, lethargy, drowsiness and death.
- Frost bite – body tissues are frozen; causes tissue damage and, in extreme cases, necrosis, gangrene and amputation.
- Slip hazards – in particular, floors will become slippery with ice.
- Freeze-burn injuries – from skin contact with very cold surfaces.

Apart from these specific effects, both environments create an increased risk of fatigue because of the stress on the body; this makes workers more prone to accidents.

Preventive Measures

Inevitably, the first course of action is to eliminate the need for workers to enter the extreme temperature environment (e.g. by automation of a process). Where this cannot be done, the environment might be regulated to reduce the temperature extremes (e.g. heating a cold workplace to more reasonable temperatures). If these options are not possible then other controls might be:

For a **hot environment:**

- Provide good workplace ventilation – moving air has a cooling effect.
- Insulate heat sources – by lagging hot pipes.
- Shield heat sources – to control radiant heat and prevent contact burns.
- Provide cool refuges – where workers can escape the heat.
- Provide easy access to drinking water or isotonic drinks.
- Provide frequent breaks and job rotation.
- Provide appropriate clothing for use in the hot work environment but consideration must be given to other workplace hazards.

For a **cold environment**:

- Prevent or protect workers from draughts.
- Shield/lag extremely cold surfaces.
- Provide warm refuges – where workers can warm up.
- Provide PPE – such as insulated jackets, trousers, boots, balaclavas, etc.
- Provide frequent breaks and job rotation.
- Provide easy access to hot food and drinks.
- Scrape, salt, or grit icy floors.

In both types of environment, information, instruction, training and supervision should be provided so that workers understand the health consequences of the environment and the early warning signs of problems.

MORE...

http://www.hse.gov.uk/temperature/index.htm

PREVENTION OF FALLING MATERIALS - SAFE STACKING AND STORAGE

Workplaces can easily become very untidy if housekeeping is not managed. Spoil heaps at excavations, piles of new materials, debris and waste can all accumulate very quickly. This can:

- Hinder or prevent the safe movement of pedestrians and vehicles around the workplace.
- Block light.
- Block access to essential services, such as fire equipment.

In some instances, stacks and piles of materials can present an immediate danger of collapse. Stacked materials, in particular can topple over if they are not stacked correctly.

Good housekeeping starts with good design and layout of the workplace; sufficient space must be allocated for the **storage of materials** at the planning stage. In particular:

- Storage areas should be clearly defined.
- Separate areas should be used for different items (for ease of identification).
- Certain materials and substances should be segregated during storage; alternatively, purpose-built secure storage (e.g. gas-bottle cages) may be required.
- Areas should be kept clean and tidy and should be routinely inspected.
- Appropriate warning signs should be displayed where necessary (e.g. where flammable materials are stored).
- Storage areas should not be used for work activities.

Stacking materials is an efficient way to use space. When stacking:

- Each stack should be for one material only (not mixed).
- A maximum stack height must be set (depending on the strength and stability of the material being stacked).
- Stacks should be vertical (not leaning).
- Pallets should be used to keep materials off the ground.
- Sufficient space must be allowed between stacks for safe movement.
- Stacks must be protected from being struck by vehicles.

Storage of Flammable Materials

Storing **flammable materials, flammable liquids** (such as solvents and gasoline) and **flammable gases** (such as LPG, e.g. butane) should be done safely. In particular:

- Flammable liquids, solids and gases should each be kept in separate stores. Oxygen cylinders should be stored separately from other flammable gases.
- External, open-air stores should be away from buildings, drains or excavations. If this is not possible:
  - There should be a fire-resistant partition separating the store from the building.
  - Drains and excavations should be sealed.
  - There should be a security fence around the store.
- Internal stores should be constructed of fire-resistant materials and provide a good level of ventilation to stop dangerous levels of gases accumulating. Completely separate buildings may be required for storing volatile flammable materials.
- Stores containing large quantities of flammables should have at least two exits. Doors and gates should be locked when they are not in use.
- Stores should have suitable warning/safety signs (e.g. flammables, no smoking, no naked flames).
- Hot works should not be carried out close to storage areas.
- Any electrical equipment installed or used in flammable storage areas should have the correct rating.
- Fire-fighting equipment should be provided.
- Stores should be inspected regularly for correct use and housekeeping.

REVISION QUESTIONS

1. What are the six main welfare requirements in any workplace?
2. Identify the protective measures to be used for working in conditions of extreme heat.
3. What are the general requirements for storage of materials in the workplace?

(Suggested Answers are at the end.)

Violence at Work

KEY INFORMATION

- Work-related violence is any incident where a worker is abused, threatened or assaulted while working. Various factors influence the risk of work-related violence, and many occupations are at risk.
- Risk of violence can be managed by providing workplace security measures, establishing safe systems of work (especially for lone workers) and providing information, instruction and training.

RISK FACTORS AND CONTROL MEASURES

GLOSSARY

WORK-RELATED VIOLENCE
Any incident in which a person is abused, threatened or assaulted in circumstances relating to their work.

Workers may be verbally abused, threatened (verbally and by physical gesture) and even assaulted as they carry out their normal work. There is a growing awareness of this issue in many countries and an understanding that abuse, threats and assault are not inevitable occupational risks that should simply be accepted and ignored.

Risk Factors for Violence

Certain occupations and types of work are associated with an increased risk of violence. In some cases there may also be the risk of violence between employees in the same workplace. The following factors are common to those occupations and situations:

- **Cash handling** – any work that involves handling quantities of cash or valuables puts workers at risk of violence associated with robbery.
- **Lone working** – any lone working that takes the worker into urban areas, or puts them in contact with members of the public at remote or private locations.
- **Representing authority** – any work where the worker represents authority, such as police, traffic wardens, etc.
- **Wearing a uniform** – uniforms are often seen as a symbol of authority, but even where they are not workers may still be singled out for abuse.
- **Dealing with people under stress** – when people are under stress they are less capable of handling their emotions and can lose control.
- **Dealing with people under the influence** - of drugs and alcohol, or with mental-health problems, when normal inhibitions on behaviour have been affected.
- **Censuring or saying no** – workers who have to give warnings, penalties, fines, or who have to refuse a service, or say no (e.g. bar staff).

Dealing with people under stress can be a risk factor for violence

Occupations at risk of violence involve one or more of these risk factors. Examples include:

- Hospital accident and emergency staff.
- Police.
- Social workers.
- Bus and taxi drivers.
- Fire-fighters and paramedics.
- Traffic wardens.
- Railway staff.
- Estate agents.

Control Measures for Violence

The first step in managing the risk of work-related violence is to find out the exact nature of the problem. Anecdotal evidence may suggest a problem, but its scale and nature may not be clear.

The extent of the problem can be investigated by:

- Collecting and analysing incident reports.
- Interviewing staff (formally or informally).
- Staff surveys.

It will then be possible to identify and implement the correct preventive measures, which will be different depending on the nature of the workplace and of the work. In general, two distinct strategies can be adopted:

- Preventing violence at a **central office**:
  - Zero-tolerance policy and prosecution of offenders.
  - Security staff.
  - CCTV cameras.
  - Security doors between public areas and staff areas.
  - Minimising queues and waiting times.
  - Clear announcements about waiting times.
  - Training for staff, e.g. providing a good-quality service, defusing aggression, etc.
  - Screens between staff and public.
  - Panic alarms.
  - Creating a pleasant environment.
- Preventing violence to workers **conducting home visits**:
  - No lone working (or no lone working in certain high-risk areas).
  - Keeping records of past incidents and vetting customers.
  - Visit-logging with a supervisor.
  - Pre- and post-visit telephone calls.
  - Training for staff, e.g. lone-working procedures, break-away techniques (self-defence), etc.
  - Always having a means of communication (e.g. mobile phone).
  - No visits after dark.
  - Parking in secure areas.
  - Not carrying cash or valuables.

MORE...

http://www.hse.gov.uk/violence/index.htm and http://www.suzylamplugh.org/

REVISION QUESTIONS

4. Give some occupations at risk of violence at work.

5. What strategies are available to avoid the risk of violence?

(Suggested Answers are at the end.)

Substance Misuse at Work

KEY INFORMATION

- Drug and alcohol abuse can have serious health and safety consequences for:
  - The worker.
  - The employer.
  - Others involved in any incident(s).
- Drugs and alcohol must be controlled by the employer through:
  - Clear policies.
  - Random testing where necessary.
  - Support for affected workers.
  - Awareness campaigns.

TYPES OF SUBSTANCES MISUSED AT WORK

There are several types of substances that may be misused at work. Notable examples include:

- **Alcohol**

  Sometimes alcoholic drinks are taken at work, or during lunchtime drinks in a local bar. Employees returning to work can then be under the influence of alcohol. Often, the effects of alcohol consumed the night before can linger into the next day with detrimental effects, especially for vehicle drivers and machinery operators.
- **Legal or Illegal Drugs (Narcotics)**

  Legal drugs can be in the form of over-the-counter, non-prescription drugs such as common analgesics and pain-killers, or stronger medicinal treatments prescribed by a doctor. Illegal drugs (such as cannabis, heroin, cocaine, etc.) may be taken by persons while in the workplace and away from it. In all cases, use of such drugs can have detrimental effects on a person, not only leading to higher risks when driving vehicles or operating machinery but also affecting their personality, responses and attitude. Other persons may therefore be put at risk as well.
- **Solvents**

  Inhalation of solvents – which may be through uncontrolled or badly controlled use of a hazardous substance (such as solvent-cleaning and paint-spraying), or from deliberate exposure ('glue-sniffing') – can affect a person's performance and can damage their health.

RISKS TO HEALTH AND SAFETY

Alcohol is an addictive drug that significantly impairs the senses and reaction times, even at low doses. Social history in many countries has meant that it is widely available, used and abused.

As discussed earlier, "drugs" is a very broad term that can be applied both to legal, prescription drugs and illegal drugs. Some prescription drugs and many illegal drugs are also addictive.

Effects of Drugs and Alcohol

The exact symptoms of alcohol and drug abuse will vary, but some general symptoms might be observed:

- Late attendance.
- Increased absenteeism.
- Reduction in quality of work.
- Reduction in work rate.
- Dishonesty.
- Theft.
- Irritability and mood swings.
- Deterioration in working relationships.

These will all be associated with cost to the employer, as well as increased risk.

Drugs and alcohol cause sensory impairment, skewed perception, impaired motor control and, in many instances, fatigue and drowsiness. There are obvious safety risks associated with drugs and alcohol, e.g. driving a vehicle or operating machinery under the influence increases the risk to the worker and to others. There are also health risks for the worker, usually associated with long-term abuse (e.g. cirrhosis of the liver due to alcohol abuse).

Risk Control Measures

The employer should collect information about the state of the problem in the workplace. Company history may show a clear pattern of drug or alcohol misuse. Of course, in some locations local culture will dictate that drugs and alcohol are severely restricted in use.

The employer should establish a clear **drugs and alcohol policy**. This policy might contain the following:

- Rules restricting access to alcohol in the workplace or during working hours.
- Statutory legal requirements prohibiting workers from being under the influence of drugs and alcohol.
- Non-statutory requirements (set by the employer) prohibiting workers from being under the influence of drugs and alcohol.
- Arrangements for any random drug and alcohol testing that workers will be subject to.
- Arrangements for workers to have access to rehabilitation and treatment programmes if they admit to having a problem.
- Disciplinary procedures for workers who refuse assistance, refuse to be tested, or who fail a test.
- Provision of information, instruction and training for workers, supervisors and managers.

Drug and alcohol awareness campaigns should also be considered.

Any drug and alcohol testing policy must be justified and clearly explained to workers. There are legal and ethical issues associated with testing regimes that must be carefully considered.

REVISION QUESTION

6. What symptoms might an employer notice in an employee who is misusing drugs or alcohol?

(Suggested Answer is at the end.)

Safe Movement of People in the Workplace

KEY INFORMATION

- Pedestrians are exposed to various hazards as they move around the workplace. These hazards can cause: slips, trip and falls; falls from height; collisions with moving vehicles; striking by moving, flying or falling objects; striking against fixed or stationary objects.
- These hazards can be controlled through the risk assessment process and by careful design and construction of the workplace. Some key controls are:
  - Use of non-slip surfaces.
  - Spill control and good drainage.
  - Designating pedestrian walkways.
  - Fencing and guarding.
  - Using signs and PPE.
  - Information, instruction, training and supervision.
  - Routine inspection and maintenance of control measures.

HAZARDS IN THE WORKPLACE

When people move around in workplaces they are exposed to a range of hazards simply by being pedestrians. These hazards can be categorised by the type of accident that they cause. Details of these categories, along with some typical conditions and environments in which each hazard might arise, follow.

Slips, Trips and Falls on the Same Level

Typical **slip** hazards:

- Smooth floor surfaces that are:
  - Inherently slippery (e.g. polished marble).
  - Wet because of spills or cleaning operations.
- Contamination of a floor with a slippery contaminant (e.g. oil or leaves).
- Frost and ice (e.g. outside pavements in winter or the floor in a freezer).

A person's footwear can make a big difference to how vulnerable they are to slipping on a floor.

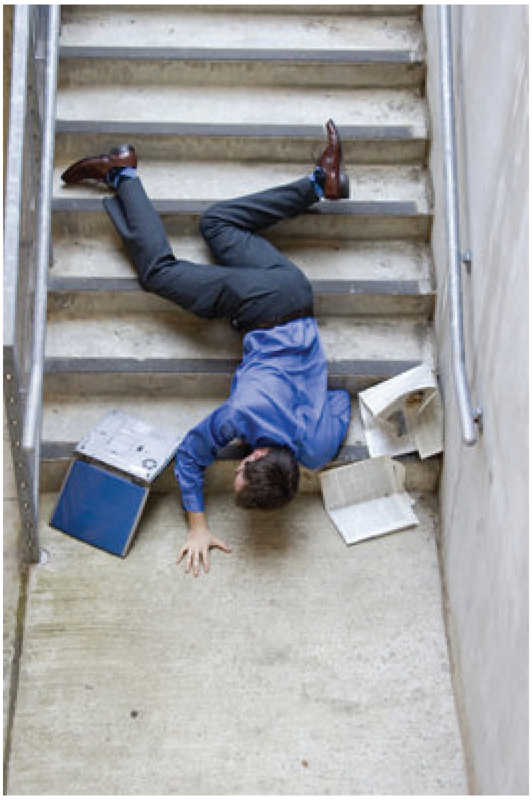
Typical **trip** hazards:

- Uneven or loose floor surfaces (e.g. broken paving slab; poorly-laid floor mat).
- Trailing cables (e.g. the cord of a vacuum cleaner).
- Objects on the floor (e.g. a bag left on the floor).

Note that people frequently 'trip over their own feet'.

When people slip or trip, they often (although not always) fall to the floor. Though falls on the same level do not always lead to serious injury, they may well lead to broken bones (especially in the hand, wrist or arm).

Steps and stairs are places of particular concern because they are locations where slip, trip and fall accidents can occur more frequently and the consequences of such accidents can be more serious.



Slips, trips and falls on stairs often cause serious injury

Safe Movement of People in the Workplace

Falls From Height

Typical hazards:

- Working next to an unprotected edge (e.g. on a flat roof; on the deck of a partly-built scaffold; by the open doors of a lift shaft when the lift is at another floor; by an excavation).
- Working on a fragile material above a drop (e.g. on a fragile roof; on a skylight).
- Using access equipment, such as a mobile elevated working platform, or cherry-picker.
- Using ladders, such as a step ladder, extension ladder or fixed vertical access ladder.
- Standing on objects to reach high levels (e.g. using a chair to reach the top shelf of a storage rack).

Falls from height (even a low height) often cause very serious injury and are a common cause of fatal injury. Construction work routinely involves work at height.

Collisions with Moving Vehicles

Typical hazards:

- Pedestrian walkways that require pedestrians to walk in vehicle traffic routes (e.g. in a warehouse or car park).
- Pedestrian crossing points.
- Exits that open onto vehicle traffic routes.
- Areas where people have to work adjacent to moving vehicles (e.g. road works; loading bays).

Accidents resulting from these types of hazard are again often the cause of serious or fatal injury.

Striking by Moving, Flying or Falling Objects

Typical **moving object** hazards:

- Automated machinery, such as a spot-welding robot.
- Unsecured objects, such as a container on the deck of a moving ship.

Typical **flying object** hazards:

- Ejected parts, such as swarf (sharp metal waste) ejected during metal drilling.
- Thrown objects, such as scaffold coupling.

Typical **falling object** hazards:

- Loads falling from height during lifting and handling operations (e.g. boxes falling from a pallet when being lifted by a forklift truck).
- Objects being dislodged during work at height (e.g. slates dislodged from a roof during roof work).
- Objects falling from height because of adverse weather conditions, or wear and tear (e.g. scaffold boards blown off a scaffold in strong winds; duct work falling from a ceiling due to deterioration of fixings).
- Toppling of unstable objects (e.g. an unsecured ladder; a poorly-stacked load on racking).

Though people are not injured by falling objects as often as they are by vehicles and falls from height, the injuries received may well be serious or fatal.

Striking Against Fixed or Stationary Objects

Typical hazards:

- Objects that project into a pedestrian area or route (e.g. stored stock metal sheets that partly project into a walkway).
- Narrow doorways in a pedestrian route.
- Low overheads (e.g. pipe work at head height above a gantry walkway).

Maintenance Activities

All of the above incidents can occur while a person is involved in maintenance activities, because maintenance engineers often work in locations and situations as a result of a fault or problem. In these areas, the hazards discussed earlier may exist; there may be spillages, damage to floors, confined areas, low ceilings, poor lighting, vehicle movements, etc.

Hazards can often occur during maintenance activities

CONTROL MEASURES FOR THE SAFE MOVEMENT OF PEOPLE IN THE WORKPLACE

The control strategies for managing the risk inherent in the movement of people in a workplace are based on basic health and safety management principles:

- Eliminate the hazard.
- Create a safe place.
- Create a safe person.

The starting point is risk assessment.

Risk Assessment

A risk assessment covering the safe movement of pedestrians in a workplace would:

- Identify the various hazards that present risk to pedestrians (as indicated above).
- Identify the groups at risk (workers, members of the public, etc.) and those who might be especially vulnerable (young children, the elderly, people with certain disabilities, such as visual impairment, etc.)
- Evaluate the risk by considering the existing controls, the adequacy of those controls and any further controls required to reduce the risks to an acceptable level.
- Be recorded and implemented.
- Be subject to review as the workplace changes, in response to incidents and perhaps periodically.

During this risk assessment it is important to consider the:

- Normal patterns of movement in and around the workplace.
- Predictable abnormal movements (such as taking shortcuts; fire evacuations).
- Accident history of the workplace, which might indicate problem areas.
- Impact of adverse weather conditions (such as wind and rain).
- Maintenance requirements of the various controls (e.g. floor surface cleaning and repair needs).

Slip-Resistant Surfaces

All floor surfaces where people may walk should be designed to ensure an appropriate level of slip-resistance. If this is not done during construction, then slip-resistant surfaces may have to be fitted or applied at a later stage (e.g. by applying a non-slip resin to an existing floor). Several factors will affect the kind of slip-resistance that is required:

- The number of people who walk on the floor.
- The footwear those people might be wearing.
- The wear and tear that the surface will be subject to (e.g. vehicle traffic).
- Foreseeable spills and contamination on the floor (e.g. chemicals).
- Environmental conditions such as weather, temperature, or sunlight.

Spillage Control and Drainage

Floors and pedestrian routes should be designed and constructed to withstand foreseeable spillages. Such spillages might simply be of water (e.g. drinks), but in other instances might involve oil, fuels (e.g. diesel), solvents or corrosive chemicals (e.g. sodium hydroxide). Spills must be controlled to prevent slip hazards and degradation of the floor surface itself, which can lead to potholes and trip hazards.

Spill control is best achieved by preventing the spill from happening in the first place. This might be done through either:

- Maintenance and inspection (e.g. of pipelines, valves or taps).
- Behavioural controls (e.g. banning drinks from an area).

If spills cannot be prevented, then measures can be taken to prevent them from contaminating walkways and floors (e.g. drip trays under leaking oil sumps; bunds around storage tanks).

Where a floor or pedestrian route is likely to get wet, then adequate drainage should be provided:

- Outdoor walkways may be subject to rainfall.
- Indoor walkways may be subject to frequent wetting during normal use (e.g. shower rooms and changing facilities) or cleaning operations (e.g. in a food production factory).

Safe Movement of People in the Workplace

Designated pedestrian walkway

Designated Walkways

The use of designated walkways is a critical control measure in many workplace situations.

Walkways can be used to try to ensure that:

- Pedestrians stay within designated areas.
- Vehicles or other hazards do not stray into pedestrian areas.

Designated walkways can be used in many different situations, such as to provide a safe pedestrian route through a car park, warehouse or loading-bay area, where vehicles will be present, or through a workshop, factory or across a construction site, where hazardous work activities (such as lifting operations) may be carried out.

Walkways might be designated by:

- Guard-rails – providing direct physical protection.
- Kerbs and pavements – such as outdoors, adjacent to a vehicle road.
- Markings on the floor.

Fencing and Guarding

Fencing and guarding can be used in a variety of situations to control hazards to pedestrians:

- Guard-rails:
  - To designate and give protection to pedestrian walkways.
  - To protect an edge where pedestrians might fall (e.g. at the edge of a mezzanine, or a path near a cliff edge or steep slope).
- Perimeter fencing: to prevent unauthorised access to construction sites.
- Guarding and perimeter fencing: to prevent access to dangerous areas near machinery (e.g. an industrial robot).
- Temporary fencing: to prevent access to a hazard such as a pothole.

Perimeter fencing with safety signs

Use of Signs and PPE

Clearly visible and easily understood signs and markings should be provided so that pedestrians (even those unfamiliar with the workplace) are made aware of hazards and what they must do to avoid them. Signs should conform to relevant standards (as detailed in Unit IGC1):

- Prohibition, e.g. no pedestrian access.
- Warning, e.g. forklift tucks operating in this area.
- Mandatory, e.g. high-visibility PPE must be worn.
- Safe conditions, e.g. fire-escape route.

Hazard-warning markings (e.g. yellow diagonal stripes on a black background) should be fixed on to pedestrian hazards, such as the edges of steps (that are not obvious) and overhead obstructions. Hazard markings might also be used on floors to indicate areas to avoid (e.g. by doors used for vehicles).

PPE may be necessary to protect pedestrians from various hazards as they move about the workplace. Some of this PPE will protect them from specific hazards inherent in an area, e.g. ear defenders in a high noise area. More importantly, PPE might be used to make them more visible as a pedestrian. High-visibility (hi-vis) clothing, such as coats, over-trousers and tabards, works by speeding up reaction times. A pedestrian wearing hi-vis can be identified as a person quickly and from a greater distance. For example, a car driver can see when a highway worker is in the road in front of them; the driver will see them sooner, be able to identify them as a person more quickly and therefore be able to take earlier evasive action.

Worker wearing high visibility clothing

Information, Instruction, Training and Supervision

Safe movement of people in the workplace inevitably requires that those people are given information, instruction and training so that they understand what is required of them and can apply it. In some instances, this can be done with the use of appropriate signs; in others, it requires the provision of specific training to communicate safety rules. As you may remember from Unit IGC1, employee induction training should incorporate information about safe movement around the workplace. This should also be provided to contractors working on site and may also be necessary for visitors.

Since people do not always follow the instructions and training that they are given, there should be an adequate level of supervision. This usually means simply enforcing the rules that have been developed about safe use of walkways, etc.

Maintenance of a Safe Workplace

Once measures have been taken to ensure that pedestrians can move around the workplace safely, some thought must be given to the maintenance of that safe workplace.

TOPIC FOCUS

Various issues might be considered for the maintenance of a safe workplace:

- **Cleaning and housekeeping**
  - Floors and walkways should be cleaned routinely to ensure that surfaces are kept free of contamination.
  - Spills will have to be cleaned up quickly and safely.
  - Housekeeping routines should be established to ensure that pedestrian routes are free of trip hazards and obstructions.
  - Floors and walkways should be inspected and repaired to keep them in a safe condition (e.g. potholes should be repaired as soon as possible).
  - Guard-rails and fencing should be inspected and repaired as necessary.
- **Access and egress routes**
  - Access and egress routes should be inspected routinely and cleaned, or repaired as necessary. This is particularly important for outdoor areas, where snow and ice can make external pedestrian walkways hazardous (in which case gritting or clearing the snow and ice may be appropriate).
  - Emergency exit routes should be kept free of slip and trip hazards and obstructions at all times.
- **Environmental considerations**
  - Lighting is essential for safe movement through a workplace, so lights should be routinely inspected and replaced/repaired, as necessary.
  - Noise levels should be kept as low as possible to enable pedestrians to hear any communications (such as PA announcements or shouts of warning), alarms (such as a fire alarm) and hazards (such as approaching vehicles).
  - Special care should be taken during maintenance activities to ensure that required standards relating to environmental considerations (lighting, noise, dust) are maintained.

The frequency of cleaning and inspection and the timescales for repairs will depend on the nature of the workplace. For example, in an engineering workshop, where swarf and waste may build up very quickly, the floor might be swept and inspected at the end of every shift, whereas weekly housekeeping might be more appropriate in an office.

Maintenance Activities

As discussed earlier, many types of incidents can occur while a person is involved in maintenance activities. It is therefore important that:

- Risk assessment of the location and intended activity is thorough enough to cover all of the eventualities mentioned.
- Control measures are sufficient to reduce the risk to as low as possible. Housekeeping is important under such conditions; engineers ensuring that a 'clean up as you go' policy is followed is the common practice.

REVISION QUESTIONS

7. Other than slips, trips and falls, name three types of hazard faced by pedestrians.
8. What are the main hazards causing slips, trips and falls on the same level?
9. Give four factors that a risk assessment should consider in relation to hazards to pedestrians.
10. What are designated walkways?
11. Identify eight control measures that might be relevant to the safe movement of pedestrians in a workplace.

(Suggested Answers are at the end.)

Working at Height

KEY INFORMATION

- Work at height results in more fatalities than any other construction activity.
- The main risks associated with work at height are falls and falling objects. These are created by hazards such as fragile roofs, sloping roofs, deteriorating materials, unprotected edges, unstable access equipment and adverse weather conditions.
- Work at height should be avoided, where possible. Where this is not possible engineering measures (e.g. edge protection) should be used to prevent falls. Where this cannot be done measures should be taken to minimise the distance fallen and the consequences of the fall (e.g. safety net).
- Scaffolds must have a securely guarded work platform, be constructed of appropriate materials by competent people, and be routinely inspected to ensure their ongoing safety.
- Mobile tower scaffolds, mobile elevated working platforms (MEWPs) and ladders each have their own set of hazards and precautions for safe use.

EXAMPLES OF WORK AT HEIGHT

GLOSSARY

WORK AT HEIGHT

Work where there is a risk of a fall liable to cause personal injury.

(Note that work at height can be subject to legal definition and the definition given here is useful for best practice. Note also that the definition does not mention ground level, so it is possible to work at height while underground, or at ground level, e.g. at the side of a sheer drop.

Construction and maintenance work often require people to work at height: Examples of workers who might be required to work at height include:

- Steel workers erecting the steel framework of a building.
- Scaffolders erecting or striking (taking down) a scaffold.
- Roofers cladding the roof of a steel-framed building.
- Demolition workers dismantling machinery in a multi-storey building.
- Welders working at the side of a deep excavation.
- Pipe fitters fixing pipework to the ceiling of a factory workshop.
- Painters working on the external walls of a building.

Some of these types of work will inherently involve work at height (e.g. scaffolding) and so those involved will be very used to working at height. This can lead to complacency. Other types of work, however, do not always involve work at height, so those involved may lack competence.

The main risks associated with work at height are:

- **The worker falling from height**. Falls from height can result in:
  - Death – working at height causes a higher proportion of fatalities than all other types of construction work.
  - Neck or spinal injuries, leading to permanent paralysis.
  - Multiple broken bones.
- **An object falling onto people below**. Falling objects can also cause severe injuries that may result in death, brain damage, paralysis, or multiple broken bones.

BASIC HAZARDS OF WORK AT HEIGHT

Vertical Distance

The vertical distance is an obvious consideration in the potential risk of injury from work at height. However, although there is some truth in the expectation that the further a person falls, the greater the injury will be, a large number of fatalities actually occur as a result of falls from a height of just two metres or less, so it is not the only important consideration.

Roofs

Roof work includes construction and maintenance of roofs, such as replacing tiles, gutter cleaning and chimney repairs. Many accidents occur during small jobs and maintenance work.

Particular dangers arise with two types of roof:

- **Fragile Roofs**

  Any roofing structure that is not specifically designed to carry loads and only has sufficient strength to withstand the forces produced by the weather should be considered a fragile roof. Roofing materials such as cement, asbestos, glass, reinforced plastics and light tongued and grooved wood covered with roofing felt are all liable to collapse under the weight of a worker.

  Fragile roofs should be clearly signed.

  The safe working method for fragile roofs is usually by the use of roof ladders or crawling boards. These are laid across the roof surface, supported by the underlying load-bearing roof members, and distribute the load of the worker over a wide area, enabling the roof structure to sustain the load safely.

- **Sloping (Pitched) Roofs**

  These are roofs with a pitch greater than 10 degrees. Falls from the edges of sloping roofs generally cause serious injury even when the eaves are low, as on a single-storey building. If the person has slipped down the roof from the ridge, they can build up speed as they move down the slope and so be projected off the edge, which adds to the force of impact with the ground and therefore to the seriousness of the injuries sustained.

Though this sloping roof is not steeply angled, the unprotected edge still presents a hazard

Deterioration of Materials

The condition of the structure on which people are working should be sound. However, materials deteriorate over time when exposed to the weather, attack by insects, etc.

Unsound materials represent a hazard in two ways:

- The material can break when a person puts his/her weight on it, causing a fall through the surface.
- The material can break off and fall to hit people below.

It may not always be evident that deterioration has occurred until it is too late, so care must be taken to ensure that materials are sound and secure.

Unprotected Edges

Where the edges of surfaces on which people are working are open, the risk of falls or falling objects is greatly increased.

This applies to a range of surfaces, including roofs, elevated walkways, scaffolding and access platforms, etc.

Unstable or Poorly Maintained Access Equipment

Access equipment includes scaffolding, towers, platforms and ladders. There are inbuilt risks in using such equipment, but they are increased if the equipment is not properly stable and secured in some way.

Any access equipment that is incorrectly sited, poorly built, or poorly secured will be inherently unstable; conditions such as overloading the equipment, high winds or overreaching can then cause a catastrophic collapse or topple.

Access equipment must be maintained correctly to ensure stability. This must be carried out by a competent person and is often subject to statutory requirements, e.g. inspection frequencies.

See later for details on the ways in which access equipment can become unstable, and the controls necessary for safe use.

Weather

The weather can increase the risks associated with working at height:

- Rain or freezing conditions can increase the risk of slipping.
- High winds can make access equipment unstable, blow loose materials off and, in extreme cases, cause workers to fall off.
- Cold conditions cause loss of manual dexterity and can lead to increased risk of muscle injuries.

Falling Materials

Objects falling from a height are capable of causing considerable damage to both people and other materials that they hit. The objects themselves may be loose structural material, waste materials, or dropped equipment or tools.

Circumstances that contribute to the likelihood of falling materials include:

- Deterioration of structures, causing crumbling brickwork or loose tiles.
- Poor storage of materials, e.g. at the edges of scaffold platforms, or in unstable stacks.
- Poor housekeeping, leading to accumulations of waste and loose materials.
- Gaps in platform surfaces or between access platforms and walls.
- Open, unprotected edges.
- Incorrect methods of getting materials from ground level to the working area.
- Incorrect methods of getting materials down to ground level, e.g. throwing.

TOPIC FOCUS

The work at height **risk prevention hierarchy is as follows:**

- **Avoid** work at height.
- Use work equipment or other measures to **prevent falls** where work at height cannot be avoided.
- Use work equipment or other measures to **minimise the distance and consequences** of a fall where the risk of a fall cannot be eliminated.

AVOIDING WORK AT HEIGHT

All work at height should be risk-assessed. The best way of managing the risks inherent in work at height is to eliminate the need to work at height entirely.

Work at height can be avoided by:

- Modifying a work process, e.g. cleaning windows from the ground by pole cleaning rather than from ladders.
- Modifying a design, e.g. erecting guard-rails or steelwork at ground level and then using a crane to put the steel and guard-rails into place.

In most instances, however, avoidance will not be possible and control measures for working at height will be required. The exact nature of the control measures should be decided during the risk assessment and will depend on various factors.

TOPIC FOCUS

Factors to consider when identifying control measures for work at height:

- Nature and duration of the task to be carried out.
- Level of competence of the persons to be involved.
- Training that may need to be provided.
- Planning and level of supervision required.
- Means of access and egress.
- Suitability of the equipment to be used, and its maintenance.
- Use of working platforms, guard-rails and toe-boards.
- Personal protective equipment, such as harnesses and helmets.
- Whether a fall-arrest system is required, or netting.
- Weather conditions.
- Health condition of the individuals (e.g. vertigo or a heart condition).
- Compliance with relevant regulations.

Finally, adequate supervision must be provided to ensure that the controls developed at the planning stage are implemented in practice.

PREVENTING FALLS AND FALLING MATERIALS

Proper **planning and supervision** of work is important to prevent falls from height and falling materials. Those responsible for such work should be experienced and should use their knowledge to ensure:

- The selection and use of correct access equipment.
- Correct provision and handling of tools and materials (especially getting them up and down from work locations).
- Adequate information, instruction and training for all persons who will be involved.

Regular inspections of the workplace, work equipment and work methods are essential to reduce the risks. Unsafe acts should not be tolerated and should be stopped immediately, ensuring all employees know why the work is being stopped, as well as the consequences if further unsafe work is carried out. Unsafe conditions should be corrected on the spot.

A simple hierarchy can be adopted to **prevent falls**:

- Provide a safe working platform with guard-rails, fences, toe-boards, etc. that are strong enough to prevent a fall.
- Where this is not possible or reasonable, provide properly installed personal equipment, such as rope access or boatswain's chairs (see later).
- If this is not possible and a worker can approach an unprotected edge, provide equipment that will arrest falls, such as a safety harness or safety net.

This last option does not prevent falls but it does minimise the distance of the fall and the consequences (i.e. injury).

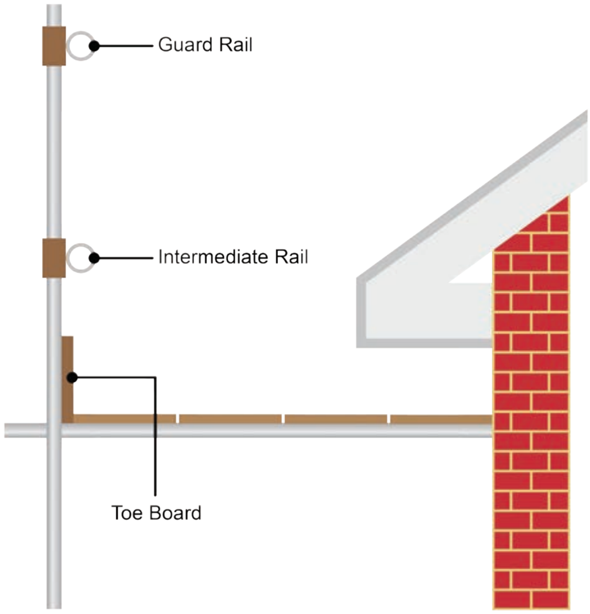
Prevention of injury caused by falling materials should be controlled using a similar approach:

- Prevent materials from falling using physical safeguards such as toe-boards and brick-guards.
- If risk remains use physical safeguards to prevent falling objects from hitting people below, such as debris netting, fans (wooden shielding angled to catch debris) and covered walkways.

An independent tied scaffold with guard-rails and toe-boards; note the debris chute for safe disposal of rubble.

Guard-Rails and Toe-Boards

Wherever possible, protection should be provided at all unprotected edges to prevent people and materials from falling. This can be achieved by means of guard-rails, toe-boards and brick-guards on scaffolding and other platforms. Guard-rails are designed to prevent people from falling, whereas toe-boards and brick-guards are principally designed to stop materials from falling.

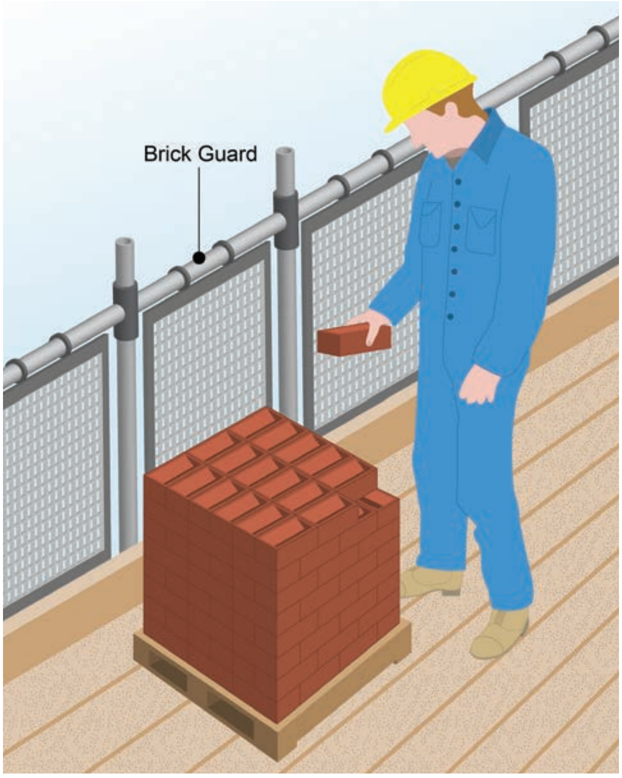


Guard-Rails on Scaffold Platform

The key characteristics of any **guard-rail** are that it should:

- Fully enclose all of the exposed unprotected edge.
- Be robust enough so that it will not bend or distort when fallen against (e.g. it should not be a chain or rope).
- Be securely fixed in position so it will withstand any foreseeable impact.
- Be high enough to prevent a person from toppling over the top.
- Not have any excessively large gaps in it through which a person could fall.

Toe-boards are usually scaffold planks laid on their edge at right angles (90°) to the working platform. They are laid at the outer edges and ends of the working platform, although sometimes the inner edge (the one nearest the building) also requires edge protection. Toe-boards prevent small objects, such as rubble and tools, from being casually kicked off the platform.



Use of a brick-guard

Brick-guards prevent a more substantial amount of material from falling and have a secondary function of helping prevent people from falling as well.

The principle of using guard-rails, toe-boards and brick-guards can be applied to the edges of flat roofs, scaffolds, mobile tower scaffolds and mobile elevated working platforms (MEWPs, such as cherry-pickers), and access cradles (as used for window cleaning).

Any gaps in edge protection (e.g. to allow access by ladder) should be the minimum required for reasonable access.

Work Platforms

Work platforms (e.g. on a scaffold tower) should be:

- Sufficiently large to allow safe use.
- Capable of bearing the loads imposed upon them.
- Fully boarded to prevent gaps that could present tripping hazards, or allow materials or people to fall through.

Usually, the platform is made up of scaffold boards resting on the scaffold framework. The boards should be free from significant defects, such as rotted timber, large cracks, split ends or large/numerous notches cut into the wood. Usually, boards should be supported across three support members. Boards should not have long overlaps beyond their supports (because of the possible see-saw effect).

Suspended Access Equipment

Suspended access equipment usually consists of a suspended cradle lowered into position from above. The cradle can be fully guarded in with guard-rails and toe-boards to provide a safe work platform.

In some instances, it is not practicable to use this sort of equipment, so it may be necessary to use personal suspended-access equipment, such as a boatswain's chair.

A boatswain's chair can be used for light short-term work. The chair usually consists of a seat with a back, a suspension point and means for carrying tools. The user should be attached to the chair by a harness to prevent falls. Control of descent is by the user, based on the same techniques as abseiling, although there should not be a single suspension point.


Boatswain's chairs being used for painting

EMERGENCY RESCUE

Emergency procedures need to be developed for reasonably foreseeable events where workers might become trapped while working at height (e.g. unable to climb back after falling in a safety harness).

The method of rescue may well be simple, such as putting a ladder up to a net and allowing the fallen person to descend. In other circumstances, the use of other work equipment may need to be considered, such as mobile elevating work platforms (MEWPs) or proprietary rescue systems.

Whatever method is selected, there should be arrangements in place capable of rescuing a person, and employers must ensure that those involved are trained in the procedures and that the equipment required is available.

MINIMISING DISTANCE AND CONSEQUENCES OF A FALL

Fall Arrest

If it is not possible to provide a safe work platform with guard-rails and toe-boards, or an alternative means of safe access (such as suspended access equipment), and workers might fall from height, then it will be necessary to provide some form of fall arrest. Fall arrest comes in two main forms:

- Collective protection systems, such as safety nets and air bags.
- Personal protective systems, such as a fall-arrest harness.

Ideally, collective protection should be used because this will protect all workers, irrespective of whether they are using their PPE correctly or not. For example, safety nets might be suspended underneath the open steel frame of a roof while workers fix the roof cladding material into place. Nets must be properly installed and securely attached by competent riggers as close as possible below the roof, to minimise the distance fallen.

Personal fall-arrest equipment usually consists of a full body harness connected to one or two lanyards (or wire rope on an inertia reel). The lanyard is connected to an anchor point during use.

Personal fall-arrest equipment should only be used by trained workers. Harnesses, lanyards and anchor points should be routinely inspected to ensure they are in safe working order.

A worker using fall-arrest equipment; note the full body harness with lanyard attached at the back.

Training and Instruction

Workers should be trained in order to work at height safely; but the exact content of the training will depend on the nature of the work and the access methods or controls used.

As a minimum, workers should be aware of the hazards posed, such as the possible presence of fragile roofing materials, unprotected edges, etc. In addition, training may be required by law for the use of some equipment. For example, those erecting or modifying scaffolds should be competent, and those driving or using mobile elevated working platforms (MEWPs) should have attended a recognised operator training course.

HEAD PROTECTION

Construction and industrial sites almost always have a risk of falling or moving objects, so they should be mandatory hard-hat areas. A hard hat protects the wearer from severe head injury as a result of:

- Impact from small objects that fall.
- Being struck by moving objects.

It will not protect the wearer from heavy impact, such as might occur if the object is very large and heavy (e.g. a scaffold tube) or is dropped from a great height (e.g. a hammer from 10 storeys up). Effective alternative methods should therefore be used to prevent falling objects and control moving objects.

In certain situations where a worker is at risk of striking their head in the event of a fall it is more appropriate for them to wear a climbing helmet rather than a hard hat. A climbing helmet is designed to give protection against falling objects and impact to the head in the event of a fall and will have a chin strap with four points of attachment.

SAFE WORKING PRACTICES FOR ACCESS EQUIPMENT

Ladders

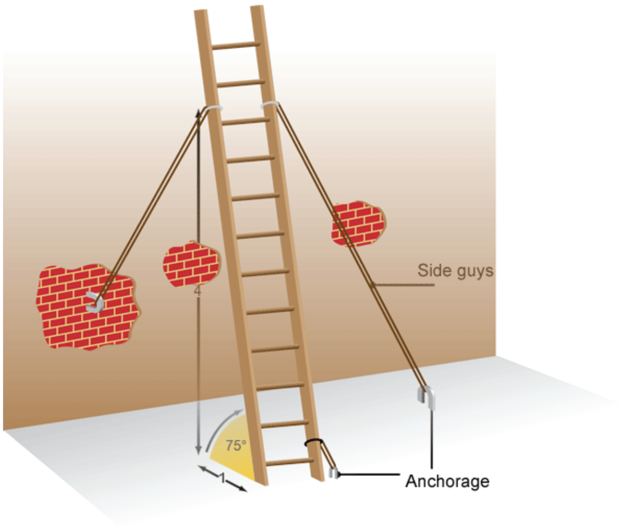
Ladders are really only suitable for short duration work that allows the worker to maintain three points of contact at all times (e.g. inspection work or painting). They are also suitable for use as a means of access and egress and are commonly used for access into excavations and onto scaffolds.

Main hazards associated with use of ladders:

- Falls from height:
  - Falling off the ladder.
  - The ladder toppling sideways.
  - The ladder base slipping out from the wall.
- Objects falling from height.
- Contact with live overhead wires and cables.

Safety precautions for use of ladders:

- Do not site or handle near live overheads.
- Site on a solid, flat base so that the feet do not sink into the ground. Weight should only be supported on the styles, never on the rungs.
- Angle of the ladder should ideally be 75° to the horizontal, or at a ratio of 1:4 distance away from the wall to height (1 out: 4 up).
- Top of the ladder must rest against a solid support.
- Ideally, the ladder should be secured at the top.
- If this is not possible, then guy ropes should be attached and secured to firm supports.
- If this is not possible, the ladder should be "footed" by someone standing on the bottom rung.



Ladder Siting

- Top of the ladder should extend far enough above the level of the working position or the platform onto which it provides access to provide a safe handhold. The stepping off point should be safe and clear.
- Only one person should climb on the ladder at any one time.
- Nothing should be carried in the hands while climbing, so that both hands are free to grasp the styles.
- Wooden ladders should not be painted as this can hide defects.

Ladder used to gain access to a scaffold platform; note how the ladder extends well above the stepping off point and how it has been secured to the scaffold.

Stepladders

Like ladders, stepladders are intended for short-duration, light works.

Safety precautions for the use of stepladders include:

- Carry out a daily check of the stepladder before use.
- Always ensure that the ladder is fully open.
- Make sure that the locking devices are in place.
- Only use on firm, level ground that is not slippery.
- Do not work off the top two steps (top three steps for swing-back/double-sided stepladders) unless there is a safe handhold on the steps.
- Avoid over-reaching.
- Avoid side-on working.

Correct use of a stepladder for a brief task where two hands need to be free (Source: Safe use of ladders and stepladders: a brief guide (2014) http://www.hse.gov.uk/pubns/indg455.pdf)

Trestles and Staging Platforms

Trestles are used with boards to provide a working platform. The HSE in the UK recommends that trestles should be:

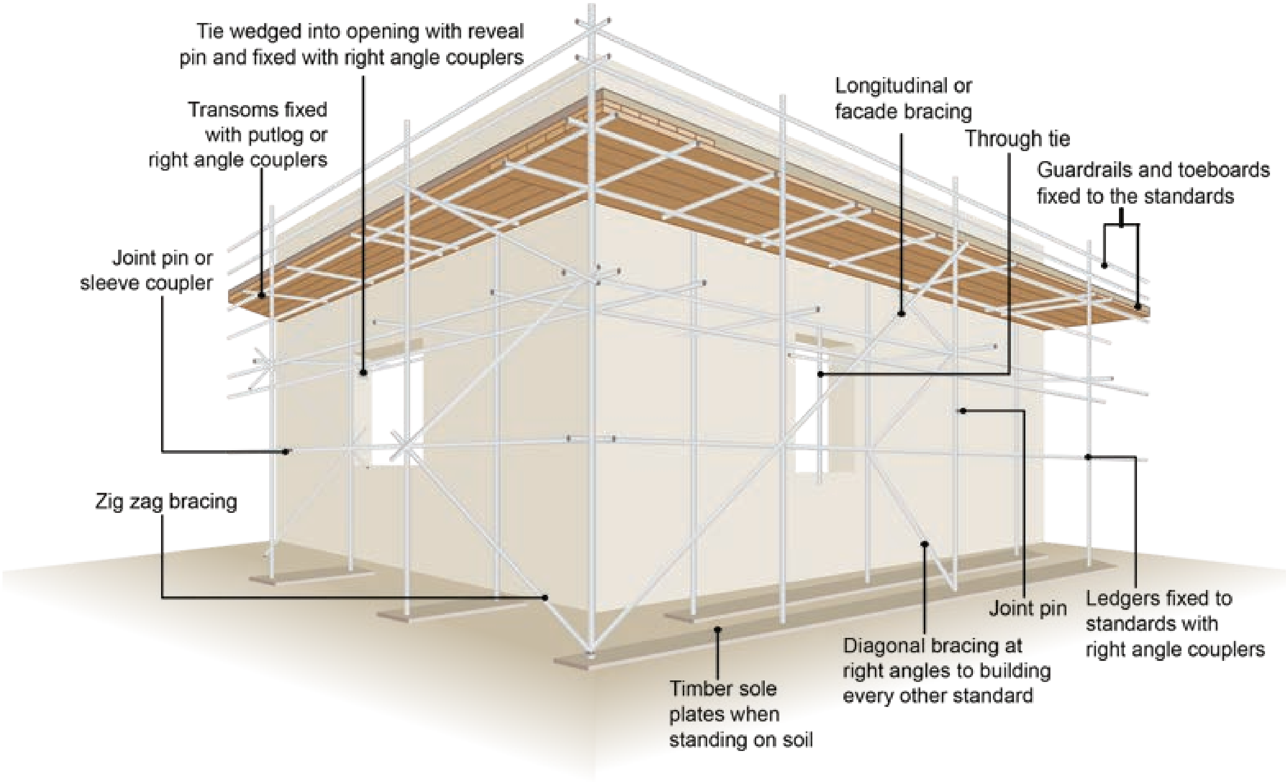
- Big enough to allow safe passage and safe use of equipment and materials.
- Free from trip hazards or gaps through which persons or materials could fall.
- Fitted with toe-boards and handrails. (If these are not fitted, the risk assessment would need to show that installing a guard-rail had been considered, and the reasons why it was not considered necessary.)
- Kept clean and tidy, e.g. no accumulation of mortar and debris on platforms.
- Not loaded in a way to risk collapse or deformation that could affect its safe use (particularly relevant in relation to blockwork loaded on trestles).
- Erected on firm, level ground to ensure stability during use.

Scaffolds

Independent Tied Scaffolds

Scaffolding is made up of the following basic components:

- **Standards** – uprights or vertical tubes used to support the load to the ground.
- **Ledgers** – horizontal tubes tying the structure together longitudinally, usually running parallel to the face of the building.
- **Transoms** – short horizontal tubes spanning across ledgers normally at right angles (90°) to the face of the building. They may also be used to support a working platform.
- **Bracing** – diagonal tubes that give the structure its rigidity.
- **Base plates** – small square metal plates that the standards (uprights) rest on to prevent them sinking into the ground.
- **Sole boards** – large pieces of timber put under the base plates to spread the load over a wide surface area when the scaffold is erected on soft ground.
- **Work platform** – fully boarded.
- **Guard-rails** – fixed to the standards (uprights) to fully enclose the work platform.
- **Toe-boards** – fixed to the standards (uprights) to provide a lip for the platform.



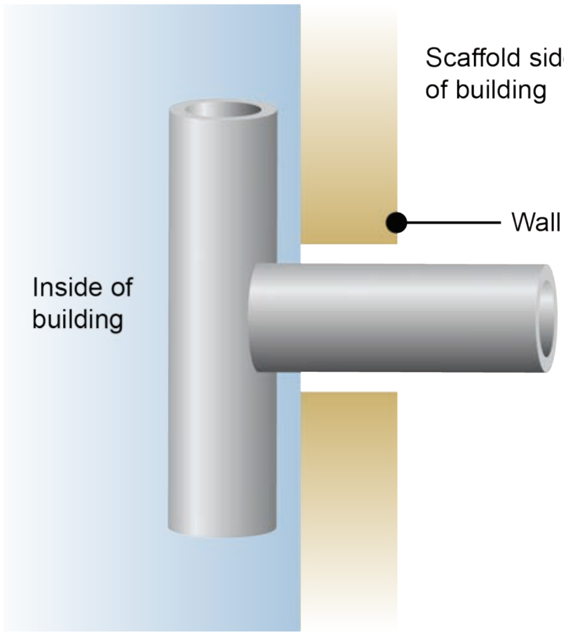
Independent Tied Scaffold

An independent tied scaffold is designed to carry its own weight and the full load of all materials and workers on the platform. It must be tied to the building where it is sited, to give stability and prevent movement.

As the total weight of the structure is supported by the ground it is very important that the ground conditions are suitable to cope with the load. Base plates and sole boards may be used to spread the weight over a large surface area.

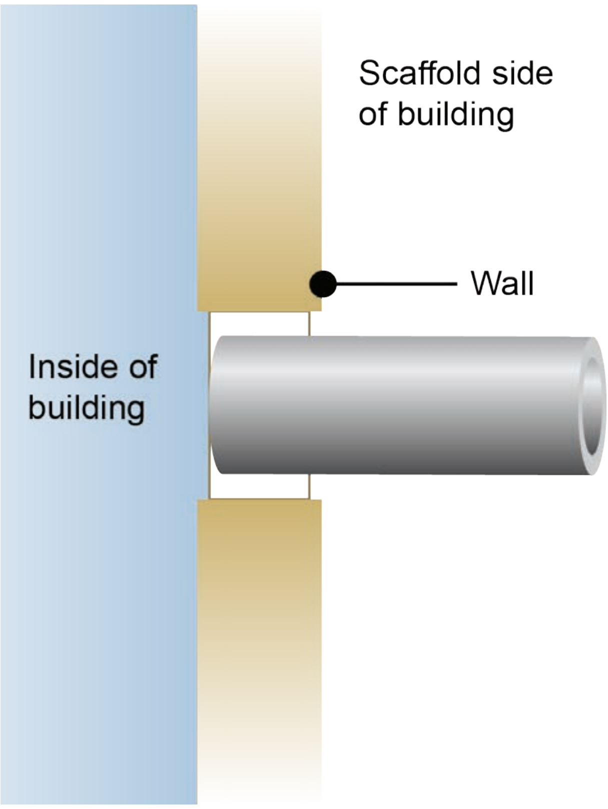
There is a number of ways in which the scaffold can be tied to the building to prevent movement:

- **Anchor bolts** – where one end of a metal bolt is screwed into the wall of the building and the other end is attached to the scaffold tubing.
- **Through ties** – where a scaffold tube extends into the building through an opening (such as a doorway or window frame). The end of the tube inside the building is coupled to another tube bridging across the opening.



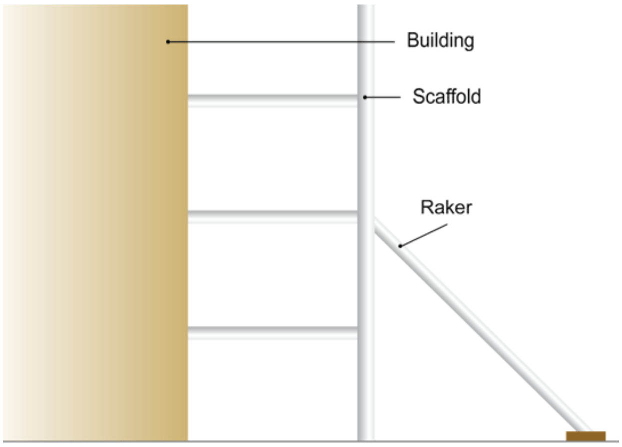
Through Tie (as seen from above)

- **Reveal ties** – a scaffold tube is coupled to a reveal pin that is wedged tightly across an opening such as a window reveal.



Plan View of a Reveal Tie

- **Rakers** – supports that push the scaffold onto the building. This system takes up space and may not be suitable in urban environments.



Side View Showing Rakers

Bracing is another important component of the scaffold and is used to stiffen the scaffold framework to prevent collapse. Bracing consists of tubes running diagonally through the structure. These tubes may run perpendicular or parallel to the building façade.

Key hazards associated with use of scaffolds:

- Falls from the scaffold during erection.
- Falls from the work platform.
- Objects falling from the platform.
- Collapse of the structure.

Scaffolds should be erected by trained workers and inspected by a competent person.

TOPIC FOCUS

Factors that might cause the collapse of an independent tied scaffold:

- Overloaded work platform.
- Scaffold built on soft ground without use of adequate sole boards.
- Scaffold not tied adequately to building.
- Insufficient bracing incorporated into scaffold.
- Standards not upright.
- Standards bent, buckled or heavily corroded.
- High winds.
- Incorrect couplers used to join tubes together.
- Scaffold struck by mobile plant.
- Scaffold erected by incompetent workers.
- Scaffold not inspected prior to use.

Mobile Tower Scaffolds

Mobile tower scaffolds are often used for painting and maintenance jobs both inside and outside buildings. They are light-duty scaffolds and their use should be restricted to light work. They have a working platform at the top which is accessible by a ladder fitted internally. They can be constructed using normal scaffolding tubes, but are mostly proprietary-made structures. The whole structure is usually mounted on wheels so it can be moved about.

A worker gains entry to the top work platform of a tower scaffold through an internal trapdoor. Note the ladder built into the side of the frame. Note also the rakers or outriggers.

Since tower scaffolds are inherently unstable they can only be built to a certain maximum height. This height is usually determined by the manufacturer as a ratio of the shortest base dimension. For example, a typical base:height ratio is 1:3.5 (meaning that if the base dimension is 1m x 1m then the maximum height will be 3.5 x 1m = 3.5m). The tower can be made more stable by increasing the base dimension by using outriggers (rakers) , by guying or by using ballast.

Main hazards associated with mobile tower scaffolds:

- Falls from the work platform.
- Objects falling from the platform.
- Collapse of the structure.
- Overturn (toppling) of the structure.
- Unintended movement of the wheels.
- Contact with live overheads.

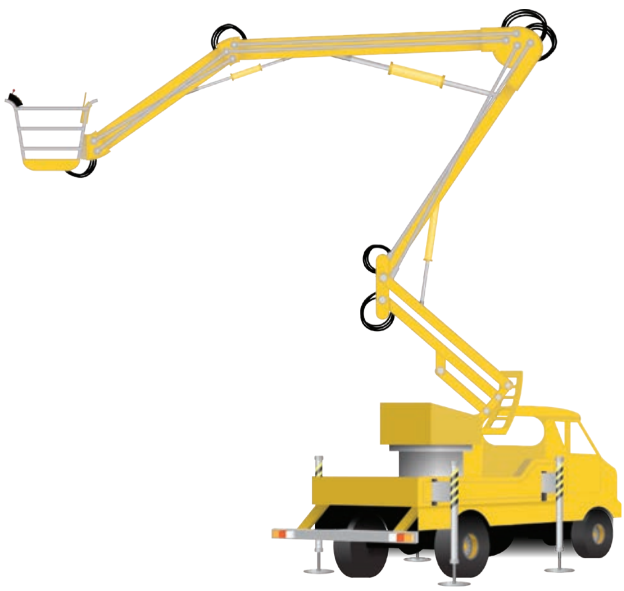
TOPIC FOCUS

Safety precautions for safe use of mobile tower scaffolds:

- Guard-rail fitted to the work platform.
- Tower must not be overloaded.
- Wheels should be locked when the tower is in use.
- Tower must be sited on firm, level ground.
- People and materials should not remain on the tower when it is moved.
- Care should be taken to avoid overheads when the tower is moved.
- Outriggers should be used where necessary to ensure stability.
- People should not climb up the outside of the tower.
- Tower must be built by trained workers.

Mobile Elevating Work Platforms (MEWPs)

MEWPs are motorised vehicles or trailers with powered extending arms supporting a work cradle. There are many different types of MEWP.



Mobile Elevating Work Platform

Working at Height

Hazards associated with use of MEWPS:

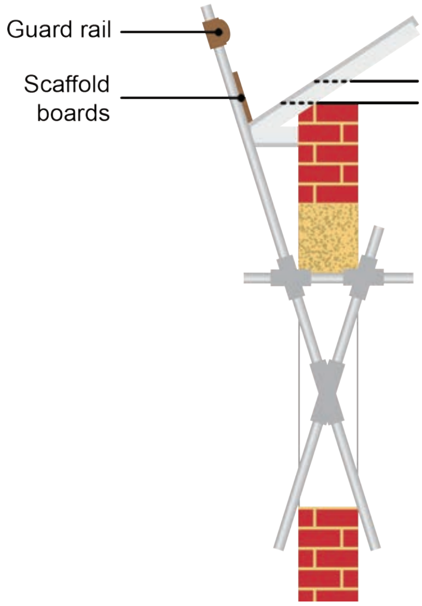
- Falls from the work platform.
- Objects falling from the platform.
- Collapse of the MEWP.
- Overturn (toppling) of the MEWP.
- Contact with live overheads.
- Unauthorised use.

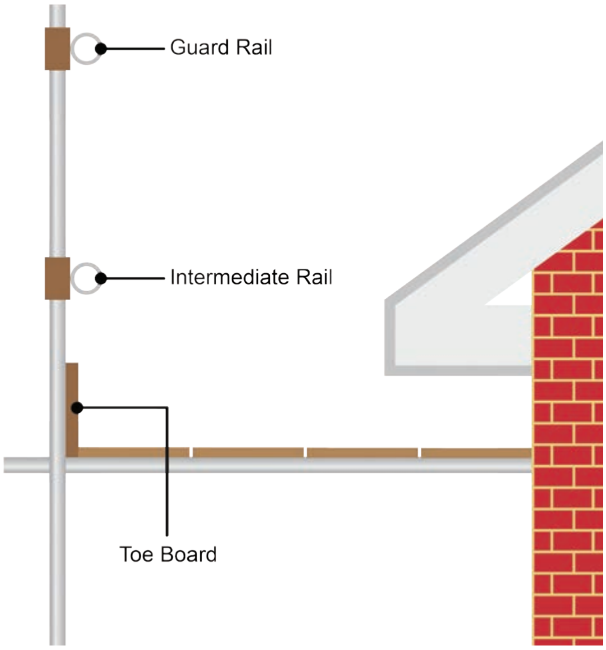
Steel workers use MEWPs to gain access to structural steel that is being lifted into place; note the use of a full body harness despite being in an enclosed cradle.

> ## TOPIC FOCUS
>
> Safety precautions for use of MEWPs:
>
> - Vehicle sited on firm, stable ground.
> - Sufficient clearance from obstructions and overheads when operating.
> - Barriers around the MEWP to prevent it being struck by vehicles or mobile plant. Barriers also act to keep people out from underneath the cradle.
> - Guard-rails incorporated into the cradle. Safety harnesses worn as an additional backup.
> - Controls of the MEWP should be inside the cradle so that the person actually working at height has some control.
> - Must not be driven with the cradle raised unless specifically designed to do so.
> - Must not be overloaded.
> - Must be inspected as an item of lifting equipment designed to carry people.
> - Use should be restricted to trained, authorised staff only.

Edge Protection Systems

An edge protection system is essentially a barrier fixed onto the existing structure in order to prevent a person walking or falling off an open edge. These are commonly used in roof work, in the form of scaffold platforms or barriers that are robust enough to withstand a person falling against them.





Scaffolds erected to form temporary edge protection around a roof

Where access to an area is required permanently, a scaffold structure may not be appropriate. There are permanent edge protection systems available that perform the same function on a long-term basis, e.g. permanent guard-rails.

INSPECTION OF ACCESS EQUIPMENT

It is good management practice (and usually a legal requirement) to inspect scaffolds routinely. Scaffolds should be inspected:

- When they are first erected.
- After any substantial alteration.
- After any event that may affect their stability, e.g. after being struck by a vehicle, or after high winds.
- Periodically (typically weekly).

Points to check would include:

- Condition of the tubes (especially standards).
- Tying and bracing.
- Condition of the work platform.
- Edge protection (guard-rails, toe-boards).
- Ground conditions (use of base plates and sole boards).
- Safe access.
- Safe working load.

Details of these inspections should be carefully recorded. It is particularly important that any defects noted are acted upon.

Other work equipment used for work at height should also be inspected, e.g. MEWPs, ladders, mobile tower scaffolds, full body harnesses, lanyards, anchor points and safety nets.

MORE...

http://www.hse.gov.uk/work-at-height/index.htm
http://www.hse.gov.uk/work-at-height/wait/index.htm

REVISION QUESTIONS

12. What is the safe method of working on a fragile roof?
13. What are the main hazards of using ladders?
14. What measures should be taken to prevent materials falling from a height?
15. In respect of scaffolding:
    (a) What is the difference between standards, ledgers and transoms?
    (b) What is the difference between tying and bracing?
16. What safety precautions need to be taken when mobile elevating work platforms are in use?
17. What is the angle at which ladders should be positioned?
18. When should scaffolding be inspected?

(Suggested Answers are at the end.)

Impact of Temporary Works

KEY INFORMATION

- Temporary works include:
  - Short-term building projects.
  - Maintenance.
  - Renovation.
  - Demolition.
  - Excavations.
- Sites where temporary works take place can become unsafe owing to the presence and use of machinery, vehicles and electricity.
- The hazards of demolition and excavations include collapse of structures, collapse into excavations, falls, flooding and hazardous substances.
- Striking buried services (e.g. electrical cables, gas pipes, etc.) can be avoided by obtaining plans, then locating and identifying buried services prior to digging.

MAIN HAZARDS AND CONTROLS RELATING TO TEMPORARY WORKS

Temporary works may include the following types of work:

- Short-term building projects.
- Maintenance.
- Renovation.
- Demolition.
- Excavations.

Sites where temporary works take place contain examples of all of the hazards that are present in other workplaces, particularly construction sites. There are also a few hazards that are specific to temporary works.

Building, Maintenance and Renovation

Building, maintenance and renovation work involves the use of hand tools, portable power tools (such as chain saws and disc cutters) and machinery (such as bench-mounted circular saws and cement mixers). It also involves the use of vehicles and plant such as dumper trucks, forklift trucks, mobile cranes and excavators.

Work Equipment

We will describe the hazards and controls relevant to hand tools, power tools and machinery in Element 4: Work Equipment Hazards and Risk Control, so here we will briefly cover some of the hazards and control measures related to one specific type of equipment – cement mixers – as well as some other general control measures for the use of work equipment.

Hazards associated with **cement mixers** include:

- Entanglement with rotating drum and internal blades.
- Entrapment by belt drive.
- Dry cement dust can be inhaled.
- Wet cement dust is corrosive and burns the skin.
- Cement mixers are powered by diesel with the resulting risk of exposure to vapours and exhaust gases.
- Noise and vibration.
- Overturning while in use.

To summarise the control measures needed when using equipment, site management should ensure that:

- Equipment is suitable for the task and environment.
- Use is restricted to competent operators.
- Information, instruction and training are provided.
- Equipment is inspected and maintained in a safe condition.
- Appropriate guards and devices are fitted and used.
- Appropriate PPE is used at all times.

Use of jackhammers or concrete breakers. Note the use of PPE, but the apparent absence of hearing protection

Vehicles

Element 2: Transport Hazards and Risk Control contains more specific information on transport hazards. Here, we will briefly consider some hazards arising from the use of two examples of vehicles used in temporary works – forklift trucks and dumper trucks – and appropriate control measures.

Forklift-truck hazards include:

- Collision with structures and pedestrians.
- Poor visibility, especially when reversing.
- Noise and vibration.
- Overturning.

Dumper-truck hazards include:

- Collision with structures and pedestrians.
- Overturning on slopes and the edge of excavations.
- Poor maintenance.
- Unauthorised use.

To summarise the control measures needed for the safe use of vehicles, site management should ensure that:

- The site is carefully designed and laid out to allow safe movement of pedestrians and vehicles around the workplace.
- Designated pedestrian walkways and vehicle routes are provided, with appropriate markings, barriers, signage and lighting for each.
- Vehicles are suitable for their intended use and environment and are maintained in safe working order.
- Drivers are appropriately qualified, medically fit and given information, instruction, training and supervision.

Movement of vehicles and heavy plant is a common site hazard that must be closely supervised

Close supervision of vehicle movement is critical on building sites, and banksmen should be used whenever vehicles are moving in congested or busy areas, or reversing.

GLOSSARY

BANKSMAN

A person who gives directions to a driver or operator, who, for some reason, cannot fully see what they are in control of. A banksman might direct an excavator operator digging a trench, a crane operator during a lifting operation, or a vehicle driver during a reversing operation, for example.

Note that the specific hazards and controls relevant to forklift trucks are described in Elements 2 and 3 of this unit.

Site Security

Building sites and areas of maintenance and renovation are inherently dangerous places. They can also act as a lure for unauthorised visitors, such as:

- Members of the public taking short cuts.
- A public right of way possibly going through the site.
- Thieves entering to steal plant or equipment.
- Children drawn by curiosity.

Good site security is therefore important, especially when the site is in an urban area.

TOPIC FOCUS

Possible options to secure a site against unauthorised access include:

- Robust perimeter fence and signs.
- Secure gates at all site access points.
- Security staff (perhaps 24-hour cover).
- Good lighting on site and on the perimeter.
- CCTV cameras and/or site alarm.
- Secure all portable equipment in locked storage.
- Remove ladders from scaffolds.
- Secure all chemicals in locked storage.
- Secure all mobile plant.
- Cover or barrier off excavations.

Where children are concerned it can be useful to liaise with local schools to promote safe behaviour.

Signs can be of limited use when trying to keep children off sites

Where there is a public right of way through the site, then every effort should be made to barrier and sign the pedestrian route.

Electricity

The hazards and controls relevant to electrical safety are described in Element 5: Electrical Safety. To summarise these controls briefly, site management should ensure that:

- Site electrical distribution systems are suitable for purpose and the site environment.
- The various protective systems available – such as fuses, earthing, low voltage (e.g. 110 V) and residual current devices – are used.
- User checks, formal visual inspections and combined inspection and testing are carried out on portable electrical equipment, as appropriate. In particular, temporary electrical distribution systems on site should be designed and installed by a competent electrician and protected from physical damage by suitable positioning, use of conduits and armoured cable.

Temporary works such as building, maintenance and renovation often bring workers and plant into close proximity with electrical distribution systems. There are two main ways in which electrical shock accidents can occur: proximity to live overhead power lines and contact with buried services. Remember that high-voltage electricity can arc through the air, so contact with an uninsulated overhead power line is not necessary for an electrical accident to occur. We will deal with the hazard of buried services later, in the section on excavations.

Accidents associated with proximity to live overhead power cables can be prevented by:

- Isolating the power supply when working in the vicinity of power lines. If power cannot be isolated, it may be possible to sleeve low-voltage power lines.
- Using safe systems of work (SSW) and permit systems to control access into danger areas.
- Using barriers, signage and goal-posts to keep plant and vehicles a safe distance from power lines.
- Using banksmen when plant is manoeuvring near power lines.
- Using non-conducting equipment, such as fibreglass ladders.

Diagram showing use of barriers, bunting and goal-posts to control proximity of plant to overhead power lines
(Based on original source HSG144 The safe use of vehicles on construction sites (2nd ed.), HSE, 2009 (http://www.hse.gov.uk/pubns/priced/hsg144.pdf))

Demolition

Demolition involves knocking down buildings to clear ground, but it also includes smaller works in maintenance and renovation, such as the dismantling of parts of structures (e.g. one part of a steel-framed building) or the removal of walls (e.g. to create open-plan rooms). The hazards associated with demolition are very similar to those encountered in other types of building work, with a few additions.

Demolition hazards vary depending on the nature of the work, but typical hazards include:

- Premature collapse of structures.
- Work at height.
- Plant and machinery.
- Contact with live overheads.
- Contact with buried services.
- Asbestos.
- Dust.
- Movement of vehicles.
- Explosives.
- Noise and vibration.
- Hazardous substances, which may be present from previous use of the building.
- Biological hazards from vermin or stagnant water.
- Sharp objects, including glass and nails from the demolition, or syringes left by trespassers.
- Manual handling.

The controls and precautions are therefore also similar to those that apply to other types of building work. Typical control measures include:

- Careful assessment and planning of the work to eliminate hazards where possible, e.g. selecting a demolition method that keeps workers away from the immediate area, such as a long-reach machine or a crane and ball.
- Elimination or control of work at height (see earlier).
- Structural surveys to assess strength and stability of the structure and adjacent structures; propping and supporting may be necessary to prevent collapse.
- Assessing the strength and stability of floors to ensure that plant, machinery and debris placed on them do not exceed the floors' tolerance.
- Disconnection of services (e.g. gas, electricity, water).
- Removal and disposal of any hazardous materials, such as asbestos, prior to demolition.
- Securing the site with fencing or hoardings to create a buffer zone and exclude unauthorised people.
- Damping down with water spray to reduce dust creation.

Excavations

The hazards of excavation work include:

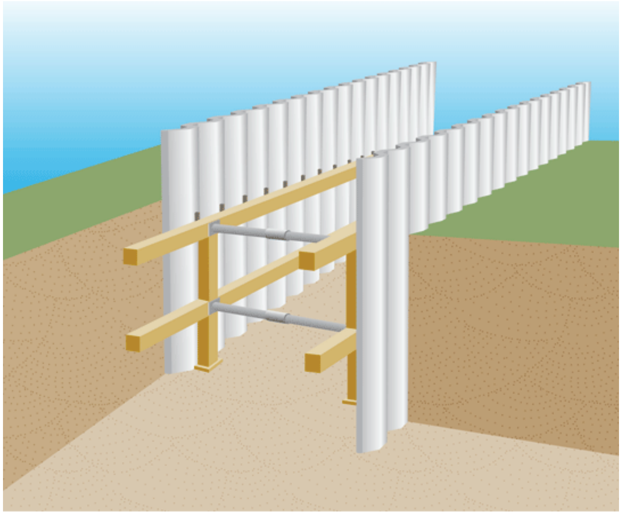
- **Collapse** – when the unsupported sides of the excavation slip and cave in. Severe crush injuries can result from even relatively small collapses because soil is very heavy. Workers buried or entrapped in soil can asphyxiate in minutes. Workers do not have to be completely buried for asphyxiation to occur; being buried to the chest will lock the rib cage and have the same effect.
- **Striking buried services** – when high-voltage electrical cables, gas pipes, mains pipes or other buried services are struck during the excavation work. This can lead to electric arcing, shock, burns and fire, or gas explosion, or rapid flooding of the excavation, not to mention major business disruption to service users.
- **People falling in** – when people fall in to the excavation from an unfenced edge or while climbing in to or out of the excavation from ladders.
- **Objects falling in** – when tools or materials fall from an unprotected edge in to the excavation and on to occupants:
  - Vehicles driving close to the side of the excavation.
  - Spoil (loose soil) piled close to the sides of the excavation.
- **Flooding** – from surface water during heavy rain, groundwater, or a ruptured water main.
- **Hazardous substances** – in particular gases and vapours. Excavations will fill with any gas that is heavier than air, such as LPG and carbon dioxide. Adjacent combustion engines (such as generators and compressors) can act as a source of exhaust fumes. The ground surrounding the excavation may contain methane or hydrogen sulphide (both produced by microbial decay), which can leach out of the soil and into the excavation, or be contaminated with hazardous materials as a result of previous activities. Excavations might need to be classified as confined spaces for these reasons.
- **Collapse of adjacent structures** – in digging an excavation the foundations of nearby buildings may be disturbed, resulting in the destabilising or collapse of the structure.

A shallow excavation revealing a collection of buried services

Prevention of Collapse

The collapse of the sides of the excavation can be prevented by:

- **Battering** - the sides of the excavation can be sloped back (battered) at an angle that is sufficiently shallow that the soil will not slip.
- **Shoring** - the sides of the excavation can be supported (shored) with metal or timber that is fixed in place inside the excavation.



Shoring the sides of an excavation by 'close sheeting'

- **Trench box** - the sides of the excavation can be temporarily supported by a metal box that can be lifted into the excavation and moved along to give a protected work area.

The type of protection method used will vary depending on:

- Type of substrate that is being excavated into.
- Length of time the excavation will be open for.
- Type of work to be carried out.
- Groundwater conditions and potential for flooding.
- Depth of excavation.
- Number of people in the excavation.

Prevention of Falls

Preventing people from falling into the excavation can be achieved by use of barriers.

- Barriers should consist of guard-rails (as for a scaffold work platform) to prevent people falling in, and toe-boards to prevent objects being kicked down into the excavation.
- Good lighting (both within the excavation and at the edges) and signage should be provided.
- Long excavations should be provided with crossing points (bridges) that should be similarly guarded in with barriers and toe-boards.
- Access to the excavation should be achieved by properly positioned and secured ladders.
- Ladders should extend five rungs above the edge of the excavation to give a secure stepping-off point. They should be routinely inspected.

Preventing material and vehicles from falling in can be achieved by maintaining a safe distance from the sides of the excavations.

- Spoil heaps should be positioned a safe distance from the excavation sides.
- Vehicles should be prevented from approaching the excavation sides by use of barriers and signage.
- If vehicles have to approach the sides of the excavation (e.g. to back-fill) then stop-barriers should be positioned to prevent vehicles from rolling in (particularly important when vehicles are reversing).
- Vehicle movement close to unsupported excavations must be minimised to prevent the side of the excavation from becoming loose as a result of vibration.
- Workers in the excavation should wear hard hats to protect them from falling objects. They should also wear steel-toecap boots.

Prevention of striking buried services can be achieved by using safe systems of work in combination with detection equipment.

- Plans of the area of the excavation should be obtained. Plans do not necessarily show the exact position of buried services, but can give an indication of the existence of services and an approximate position.
- The buried services should be located using surface clues and detection equipment. Various devices can be used to detect different types of service (such as metal detectors, hum detectors, cable detectors, ground radar).
- The buried services should be uncovered by careful digging by hand.
- The exposed services should be identified to ensure that they are those that were expected and be clearly labelled so that their position is easily seen. It may be necessary to support pipes (e.g. gas pipes) where ground underneath is being removed.
- Digging with mechanical equipment can now commence.

Hazardous gases and vapours may require that the excavation is classified as a confined space, in which case a specific confined-space risk assessment and SSW will need to be developed. The excavation should be made subject to a permit-to-enter. Forced-air ventilation, air monitoring and respiratory protective equipment may be necessary.

Inspection Requirements

Excavations, like scaffolds, can become unstable and unsafe if not maintained in good order. They can deteriorate rapidly as a result of environmental conditions and are liable to catastrophic failure. It is essential that they are inspected routinely to ensure they are in a safe condition.

Excavations should be inspected by a competent person:

- Before the start of every work shift.
- After any accidental fall of material.
- After any event likely to affect strength and stability.

Records of these inspections should be kept on site, and remedial work must be undertaken as soon as possible to repair any defects noted.

REVISION QUESTIONS

19. Identify the main hazards associated with excavation work.
20. What is battering?
21. How can the hazards of buried services be avoided?
22. When should excavations be inspected?

(Suggested Answers are at the end.)

SUMMARY

This element has dealt with certain workplace hazards and the associated risk controls available.

In particular, this element has:

- Outlined minimum welfare provision as: access to drinking water; toilets; washing facilities; changing rooms and accommodation for clothing; and places to rest and eat food.
- Identified basic workplace environment standards for: seating; ventilation; heating; and lighting.
- Outlined the effects of working in extreme temperatures and relevant control measures.
- Discussed the prevention of materials from falling by ensuring safe stacking and storage.
- Discussed risk factors for work-related violence and control measures.
- Outlined types of substances misused at work, as well as the risks to health and safety of drug and alcohol misuse, and the control measures available.
- Outlined the various hazards that pedestrians are exposed to as they move around the workplace and categorised them as: slips, trips and falls; falls from height; collisions with moving vehicles; striking by moving, flying or falling objects; striking against fixed or stationary objects.
- Noted how these hazards can be controlled by the risk assessment process and by careful design and construction of the workplace. Key controls were identified, such as the use of non-slip surfaces; spill control and good drainage; designating pedestrian walkways; fencing and guarding; signs and PPE; information, instruction, training and supervision; and routine inspection and maintenance routines.
- Described the main risks associated with work at height as falls and falling objects, created by hazards such as fragile roofs, sloping roofs, deteriorating materials, unprotected edges, unstable access equipment and adverse weather conditions.
- Outlined how work at height should be avoided; or engineering measures (e.g. edge protection) used to prevent falls; or measures taken to minimise the distance and consequences of a fall (e.g. safety nets).
- Discussed the hazards and precautions relevant to scaffolds, mobile tower scaffolds, mobile elevated working platforms (MEWPs) and ladders, as well as the inspection requirements for such equipment.
- Outlined some of the main safety hazards associated with temporary works, including building, maintenance, renovation and demolition, and their respective controls, such as: machinery, vehicles and electricity, safe demolition methods, with emphasis on site security in order to keep non-workers away from these hazards.
- Described hazards of excavations as collapse, striking buried services, falls, falling objects, flooding, and hazardous substances.
- Outlined the safety precautions relevant to each of these hazards, such as: supporting the sides of the excavation; use of cable detection equipment to locate buried services; use of barriers; as well as the inspection requirements for excavations.

Exam Skills

INTRODUCTION

To pass the NEBOSH International General Certificate you need to perform well during the exams. You only have two hours and your performance will be related to two key factors:

- The amount that you can remember about the elements you've studied; and
- Your success in applying that knowledge to an exam situation.

Being good at both aspects is essential. Being calm under exam pressure is pointless if you do not have a good knowledge of the information required to answer the exam questions.

Here we will consider some practical guidelines that can be used to increase success in the exam. Then you will find Exam Skills questions for you to answer at the end of each element, starting with this one.

EXAM REQUIREMENTS

The GC2 exam consists of two sections:

- Section 1 contains one question, which is likely to consist of a number of sub parts. This question in total is worth 20 marks.
- Section 2 contains ten questions, with each question being worth eight marks.

There is no choice of questions in the exam - all questions must be answered. The exam in total lasts two hours and NEBOSH recommend that you spend:

- about half an hour on Section 1; and
- about one and a half hours on Section 2.

For advice on exam technique, please refer back to Unit IGC1, end of Element 1.

EXAM SKILLS PRACTICE

At the end of each element there is an Exam Skills question (or two) for you to attempt, with guidance on how to answer in addition to a suggested answer outline. This includes an Answer Plan - all of the points listed in this would attract marks and you will see most of them developed in the suggested answer itself.

Remember that when answering exam questions, information from additional reading and personal experience may be included. Examining bodies encourage this and it will enhance your answers.

There is a time estimate at the beginning of each Exam Skills activity. Don't worry if the activity takes you a little longer than this - the timings are just there as a rough guide.

QUESTION 1

A roofing contractor is required to carry out extensive repair work on a fragile roof on a large manufacturing building.

(a) **Outline** the factors that should be considered in the selection process for hiring the roofing contractor. (8)

(b) **Identify** the main risks to the contractors from working at height. (4)

(c) **Identify** possible control measures for the erection of an independent tied scaffold. (8)

Based on IGC2, June 2010, Question 1

QUESTION 2

Excavation work is being carried out on a construction site.
Identify the control measures needed to reduce the risk to workers. (8)

Based on IGC2, June 2012, Question 9

APPROACHING QUESTION 1

In GC2 the first section is a longer, 20-mark question, which is typically broken down into smaller parts. NEBOSH advise that you allow yourself half an hour for this question – here you can allow yourself a little longer to work through the process, but be aware that on exam day you will be under greater time pressure.

This question may look daunting, consisting of three sub-sections, but you should approach it in the same way that you would a simpler, 8-mark question. Action words are used to indicate the level of depth that you are required to provide. Note, however, that it is possible that a 20-mark question may cover topics from more than one element.

Think now about the steps you would take to answer the question:

1. The first step is to read the question carefully. This question requires you to outline and identify – as always be careful that you understand the correct level of depth required, as many good candidates lose marks for giving a list rather than an outline.

2. Next, consider the marks available. It would be sensible to assume that you need to outline eight factors for part (a) (though adding a couple of additional factors may maximise your chances of getting full marks here). In part (b) you should identify at least four main risks from working at height. In part (c) you should identify at least eight controls for erection of the scaffold.

3. Now highlight the key words. In this case they might look like this:

   A roofing contractor is required to carry out extensive repair work on a fragile roof on a large manufacturing building.

   (a) Outline the factors that should be considered in the selection process for hiring the roofing contractor. (8)

   (b) Identify the main risks to the contractors from working at height. (4)

   (c) Identify possible control measures for the erection of an independent tied scaffold. (8)

Read the question again to make sure you understand about roof work, contractor selection and scaffolds. (Re-read your notes if you have to.)

4. The next stage is to develop a plan.

Here, your answer plan is likely to take the form of a bullet-pointed list that you need to develop into a full answer based on the key words that you have highlighted.

Now have a go at the question. Draw up an answer plan, and then use it as the basis to write out an answer as you would in the exam.

Key hint: think of this as three separate questions if that helps.

When you have finished, compare your plan and full answer with those that follow.

SUGGESTED ANSWER

Plan

Factors to Consider in Contractor Selection

- References.
- Insurance.
- Trade association memberships.
- Maintenance of equipment.
- Experience of similar works.
- Training of staff.
- Method statement suitability.
- Risk assessment quality.
- Accident history.
- Enforcement actions.
- Health and safety policy.
- Equipment to be used.
- Maintenance of equipment.
- Control of sub-contractors

Risks to Contractors from Work at Height

- Falls from height.
- Falling objects.
- Falls through fragile roof.
- Contact with live services/cables.
- Injuries due to tools in use.
- Effects of weather (from sunburn to slips on ice).

Controls for Erection of Independent Tied Scaffold

- Correctly designed for use and load.
- Designed for weather.
- Equipment to be used.
- Stable ground.
- Base plates and sole plates.
- Scaffold not damaged and in good condition.
- Erected by competent persons.
- Inspected before use.
- Scaffolders wearing fall-arrest equipment.
- Securely tied to structure/building.
- Protected from vehicles.

POSSIBLE ANSWER BY EXAM CANDIDATE

(a) The following factors should be considered when selecting a roofing contractor. References should be checked to ensure that previous clients were satisfied with the work carried out, and to ensure that works of a similar nature and size to the proposed project have been delivered successfully. Certificates of insurance should be checked to ensure that adequate public liability and employer's liability cover is carried by the contractor. The level and quality of health and safety training provided to employees should be considered, and preference given to organisations that demonstrate such commitment to employee training. The organisation's health and safety management system should be considered, such as the suitability of the health and safety policy and the process for reporting and recording of accidents, and the processes in place for checking and controlling sub-contractors. With regard to the safety of the project the suitability and quality of the risk assessments should be assessed, ensuring that the risk assessments are site-specific. Method statements should be sufficiently detailed and demonstrate how control measures will be implemented to reduce the risk to the workers. Finally, consideration should be given to the safety of the equipment to be used on-site, the suitability of the equipment for the environmental conditions and its maintenance.

(b) The main risks to the contractors from working at height include falls from height, falls through a fragile roof, contact with live services such as power cables, and the effects of exposure to adverse weather conditions (from sunburn through to slips on ice).

(c) Possible control measures to be implemented when erecting an independent tied scaffold include ensuring that the scaffold is designed for the load it is intended to take, and that it is erected by a competent scaffold contractor on firm, level ground with base plates used to spread the load. The scaffold components should be free from damage. The scaffolders should wear fall-arrest equipment during the assembly to prevent falls. The scaffold should be tied securely to the building with the appropriate number of ties to prevent collapse, taking into account possible loads and adverse weather conditions.

REASONS FOR POOR MARKS ACHIEVED BY CANDIDATES IN EXAM

- In part (a) problems that the candidates encountered included limiting their answers to previous work of a similar nature, and reviewing the health and safety policy.
- In part (b) some candidates confused risks (which were required) with hazards and provided the wrong information.
- In part (c) some candidates misread the question and detailed the components used for the erection of the scaffold rather than the control measures to be used during the erection of the scaffold.

APPROACHING QUESTION 2

Think now about the steps you would take to answer the question:

1. The first step is to read the question carefully. This question requires you to identify, so you don't need to give much detail – as we saw earlier, if asked to "identify" you are expected to "select and name", so in this case you should name the control measures needed to reduce risk to workers.

2. Next, consider the marks available. In this question there are eight marks. It would be sensible to assume that you need to identify eight or more controls to gain the eight marks (adding a couple of additional controls may maximise your chances of getting full marks here). However, don't go overboard – watch the time! The question should take around eight minutes in total.

3. Now highlight the key words. In this case they might look like this:

   Excavation work is being carried out on a construction site.
   Identify the control measures needed to reduce the risk to workers. (8)

4. Read the question again to make sure you understand it and have a clear understanding of controls to protect workers. (Re-read your notes if you need to.)

5. The next stage is to develop a plan – there are various ways to do this. Your answer must be based on the key words you have highlighted. Remind yourself, first of all, that you need to be thinking about "How are pedestrians kept separate from vehicles?" and then "How else can we ensure the safety of pedestrians?"

Now have a go at the question. Draw up an answer plan, and then use it as the basis to write out an answer as you would in the exam.

Take care to keep an eye on the time when answering – it is very easy to spend too long on a question and there are only eight marks available, no matter how long you spend on it!

When you have finished, compare your plan and full answer with those provided.

SUGGESTED ANSWER

Plan

Excavation Controls

- Shoring or drag boxes to prevent trench collapse.
- Stop blocks to prevent vehicles driving into trench.
- Provision of safe access into excavation (ladders, etc.)
- Pre-dig checks for services (cable scans, checking plans).
- Supporting adjacent buildings/checks to ensure foundations aren't undermined.
- Barriers to prevent pedestrians falling in.
- Gas checks to ensure breathable atmosphere.
- PPE to protect against possible contamination (contaminated land).
- PPE and training in biological hazards.
- Statutory inspections of the excavation.

POSSIBLE ANSWER BY EXAM CANDIDATE

Possible controls to reduce the risk to workers near excavations on a construction site include:

- *Before digging, the excavation site should be checked for underground services, including power and gas mains. This should be carried out by checking site plans and using cable detectors.*
- *Supporting the sides of the excavation to prevent collapse using shoring or drag boxes. An alternative is to batter back the sides of the excavation to a safe angle. All material excavated should be stored a safe distance from the excavation to prevent it from falling in onto workers.*
- *Provision of stop blocks to prevent vehicles driving or reversing into the excavation.*
- *Use of barriers to prevent pedestrians from falling into the excavation.*
- *Provision of safe access means for those entering the excavation (e.g. a ladder) and so that they can exit safely.*
- *Those working in the excavation may need gas detectors to ensure that the atmosphere is breathable, testing for toxic gases but also to ensure an adequate oxygen supply.*
- *PPE may be needed to protect workers from contamination (e.g. chemicals in contaminated land), or biological hazards.*
- *In order to ensure ongoing safety the excavation should be inspected before the start of every shift, after any fall of earth and after any event likely to affect stability.*

REASONS FOR POOR MARKS ACHIEVED BY CANDIDATES IN EXAM

There were some good answers to this question, although some candidates did talk about general controls, such as permits-to-work and risk assessments, which didn't attract marks.

TRANSPORT HAZARDS AND RISK CONTROL

ELEMENT 2

LEARNING OUTCOMES

On completion of this element, you should be able to demonstrate understanding of the content by applying what you have learnt to familiar and unfamiliar situations. In particular, you should be able to:

1. Explain the hazards and control measures for the safe movement of vehicles in the workplace.
2. Outline the factors associated with driving at work that increase the risk of an incident, and the control measures to reduce work-related driving risks.

Contents

Safe Movement of Vehicles in the Workplace

KEY INFORMATION

- Vehicle operations are a hazard to the vehicle driver, as well as pedestrians, other drivers and passengers. Hazards include:
  - Those relating to vehicle movement, which include driving too fast, reversing, quiet machinery and poor visibility.
  - Non-movement-related hazards, which include loading, unloading, securing and sheeting of loads, coupling and maintenance work.
- Common accidents involve:
  - Vehicles overturning.
  - Collisions with pedestrians, other vehicles or fixed structures.
- These hazards can be controlled through the risk assessment process and by careful management of the site, the vehicles and the drivers:
  - The site should be designed, constructed and maintained to allow safe vehicle movement and to separate vehicles from pedestrians.
  - Vehicles should be suitable for their intended use and workplace environment, and maintained in safe condition.
  - Drivers should be appropriately qualified, medically fit and given information, instruction, training and supervision.

HAZARDS AND RISK FROM WORKPLACE TRANSPORT OPERATIONS

Typical Hazards Relating to Vehicle Movements

When vehicles move around in workplaces, they are a hazard to:

- Pedestrians.
- Other vehicles (and their occupants).
- The driver (and other occupants).

Vehicle accidents are responsible for many serious and fatal injuries and also cause a significant amount of property and equipment damage. Hazards related to vehicle movement – along with some typical conditions and environments in which each hazard might arise – include the following:

- **Driving too fast** – often associated with driver error – is a major cause of vehicle collisions and vehicles overturning. The effects of driving too fast are worsened by movements across uneven ground, or sloping surfaces and around bends. Loads may move as a result of abnormal movements and may fall from vehicles. Braking when driving too fast may be ineffective and more hazardous on wet, icy or slippery surfaces.
- **Reversing** – limits a driver's vision and puts the whole length of a vehicle in the direction of travel. Without rear-vision devices (such as cameras) the driver's vision may be impaired; without reversing alarms pedestrians may not see or hear the approach of a reversing vehicle.
- **Silent operation of machinery** – not only are vehicle engines now more quiet but auxiliary machinery and equipment, such as loaders, cranes, refrigeration plant, etc. may also be quiet or silent, and therefore may not be heard by pedestrians or other drivers.
- **Poor visibility** – especially around loads, wide or long vehicles, or while vehicles reverse – causes many collisions. Vehicle entrance and exit points also create blind spots and changes in light levels.

Typical Non-Movement-Related Hazards

Vehicles do not only present a hazard when they are moving. Some vehicle hazards occur when other types of activity are being carried out on the vehicle:

- **Loading** – both manual and mechanical loading of vehicles can create risk, e.g. the manual-handling risk associated with lifting crates into the back of a lorry, or the risk of collision when loading a flat-bed lorry using a forklift truck.
- **Unloading** – both manual and mechanical unloading can create risk, e.g. tipping operations can result in the vehicle overturning, or people being struck by the material being tipped.
- **Securing and sheeting** – when workers have to climb onto a vehicle in order to secure the load, e.g. a driver might have to climb onto the top of a lorry to sheet over the load to prevent it blowing out when moving at speed. Alternatively, they may have to climb onto the top of a road tanker to close hatches. Both of these operations involve work at height.

- **Coupling** – when vehicles are attached to trailers or other towed equipment, there is potential for collision and crushing.
- **Maintenance work** – when mechanics have to access various parts of the vehicle and may have to work at height, or under the vehicle.

Typical Risks Associated with Vehicle Operations

Loss of Control and Overturning

A driver may lose control of their vehicle for various reasons:

- Driver error (e.g. driving too fast).
- Environmental conditions (e.g. mud on the road).
- Mechanical failure (e.g. brake failure).

Depending on the type of vehicle being driven, this loss of control may result in a skid, collision or overturn of the vehicle.

When a vehicle overturns, the driver can easily be trapped or crushed between the vehicle and the floor unless precautions are taken to retain the driver in a safe location – this is why seat belts are so important.

Some vehicles, because of their design or environment of use, are more likely to overturn than others. Forklift trucks (which have a very short, narrow wheel-base) and dumper trucks (which have a high centre of gravity and are often used on rough terrain) are frequently involved in overturning accidents.

Forklift truck

TOPIC FOCUS

Factors that may cause a **forklift truck** to overturn:

- Driving around corners too quickly.
- Uneven loading of the forks.
- Driving over potholes.
- Driving with the load elevated, especially when going around corners.
- Uneven tyre pressures.
- Driving across a slope rather than straight up or down the slope.
- Excessive braking.
- Collisions, especially with kerbs.

Collisions

Collisions can occur between the vehicle and:

- Other vehicles, e.g. between two lorries manoeuvring at a depot.
- Pedestrians, e.g. between a car in a staff car park and a member of staff leaving work.
- Fixed objects, e.g. between a forklift truck and the support leg of racking in a warehouse.

Vehicle **entrance and exit points** – such as the forklift truck entrance point from an outside yard area into a workshop – are areas of particular concern. These parts of a building tend to have a high incidence of vehicle collisions because of the:

- Concentration of vehicles through these routes.
- Presence of blind spots (places that the driver cannot see).
- Changes in light levels that may occur (from brightly lit to dark and gloomy, or the reverse) – the driver's eyes take a while to adapt to the new light level.

Remember that some of the highest risk situations occur when pedestrians have to interact with vehicles. Any collision between a vehicle and a pedestrian is likely to lead to serious or fatal injury.

TOPIC FOCUS

Factors that increase the risk of vehicle collisions:

- Driving too fast.
- Inadequate lighting.
- Reversing without the help of a banksman (see later).
- Blind spots, such as corners and entrances.
- Bad weather conditions (e.g. rain).
- Obstructed visibility (e.g. an overloaded forklift-truck driving forwards).
- Poor design of pedestrian walkways and crossing points.
- Lack of vehicle maintenance (e.g. brake failure).

CONTROL MEASURES FOR SAFE WORKPLACE TRANSPORT OPERATIONS

The control strategies for managing the risk inherent in vehicle operations are based on the usual basic health and safety management principles:

- Eliminate the hazard.
- Create a safe place.
- Create a safe person.

The starting point is risk assessment.

Risk Assessment

A risk assessment covering the vehicle operations in a workplace would:

- Identify the various hazards, by establishing the vehicle operations taking place in or from the workplace and the types of foreseeable accident that might occur.
- Identify the groups at risk (pedestrians, the driver, other drivers, etc.) and those who might be especially vulnerable (young children, the elderly, people with certain disabilities, such as the visually impaired, etc.)
- Evaluate the risk by considering the existing controls, the adequacy of those controls and any further controls required to reduce the risks to an acceptable level.
- Be recorded and implemented.
- Be subject to review as the workplace changes, in response to incidents, and perhaps periodically.

The measures necessary to control the risks created by vehicle operations can be grouped into three main categories:

- Safe site (the workplace environment).
- Safe **vehicles.**
- Safe **drivers**.

Safe Site (Workplace Environment)

Careful design and construction of the workplace can eliminate or reduce the risks created by vehicle operations. The following factors should be considered:

- Vehicle-free zones – it may be possible to eliminate the hazard by creating pedestrian-only areas.
- Pedestrian-free zones – since pedestrians are usually the group at greatest risk during vehicle manoeuvring operations it may be possible to eliminate them from certain parts of the workplace.
- Vehicle traffic route layout – good design of roads and routes can be used to keep vehicles at a distance from pedestrian walkways and other vehicles. One-way systems are an effective method of reducing the risk of collisions between vehicles. Reversing should be eliminated where possible through the introduction of one-way systems and turning circles, where appropriate.
- Segregation of vehicles and pedestrians – wherever possible, pedestrians should be provided with a separate walkway. It may be necessary to place barriers on this route to provide additional physical protection. In some situations (such as in loading bays), safe havens should be provided to which pedestrians can retreat during vehicle movements.

  Where barriers cannot be used, segregation might be achieved by marking pedestrian walkways on the floor.

  Crossing points may be implemented to allow pedestrians to cross traffic routes safely.
- Separate site and building entrances should be provided for vehicles and pedestrians so that they are not forced into close proximity at these busy areas.
- Appropriate signage should be used to alert vehicle drivers to hazards on their route (such as lower overheads).
- While barriers can protect pedestrians from vehicles, they can also be used to protect structures that might be at risk of damage or collapse in the event of a collision, e.g. in a warehouse, racking may be protected with barriers at vulnerable locations.
- Environmental considerations should also be taken into account:
  - Good standards of lighting should be present on traffic routes.
  - Good visibility is essential, so that drivers have unobstructed views from their vehicles. Blind spots should be eliminated by careful traffic route design; where this is not possible, aids such as mirrors, CCTV and transparent doors should be provided.
  - The surface of the traffic route must be suitable for the vehicles using it, with attention paid to its strength, stability, grip characteristics and drainage.
  - Gradients and changes of level should be avoided, but if this is not possible they must not exceed the capabilities of the vehicle using the traffic route.

Safe Movement of Vehicles in the Workplace

The above controls must also be reinforced by the implementation of **site rules** for drivers and pedestrians and driver training. These rules must be strictly enforced and adhered to. Visiting drivers (such as delivery drivers) should be provided with information about the site rules.

These rules include **speed limits**, which should be set for traffic routes and then clearly indicated by signage, and enforced. Traffic-calming measures – such as speed bumps – might be used where experience shows there is a problem with vehicles speeding.

TOPIC FOCUS

Control measures that can reduce the risk of accidents from reversing vehicles:

- Avoidance of reversing by implementing one-way traffic systems.
- Segregation of pedestrians and vehicles or the provision of refuge areas.
- Good vehicle selection so that drivers have adequate visibility.
- Provision of audible reversing alarms and flashing beacons.
- Provision of mirrors at blind spots to see approaching pedestrians.
- Use of high-visibility clothing.
- Ensuring that the area is well lit.
- Provision of banksmen (see later).
- Training for drivers and pedestrians working in the area.

Pedestrian direction sign

All control measures should also be maintained in good order. This may require routine inspection regimes, cleaning regimes and repair/replacement as necessary.

It will usually be necessary to develop safe systems of work for vehicle operations. These safe systems should identify the site procedures and rules that must be followed. For example, many workplaces prohibit vehicles from reversing without the aid of a banksman (see later).

Safe Vehicles

The range of vehicles that might be used for work purposes is large, from cars, vans and lorries used on public roads to 200-tonne quarry trucks. In spite of this great variety of vehicles, there are some basic principles that can be applied.

TOPIC FOCUS

Vehicles should be:

- Suitable for their intended use.
- Suitable for the environment and conditions in which they are used.
- Maintained in safe working order.
- Only driven by suitably trained, qualified staff.
- Inspected routinely before use.

Where necessary, vehicles should also be fitted with:

- Seat for the driver (and seats for any passengers).
- Driver protection and restraint systems, such as:
  - Seat belt.
  - Roll bar or roll cage to protect the driver in the event of overturning.
  - Guard to protect the driver in the event of falling objects.
- Horn.
- Visibility aids, such as cameras and mirrors.
- Audible reversing alarm to warn pedestrians.
- Beacon or flashing light to warn of an approaching vehicle.

GLOSSARY

ROLL BAR OR ROLL CAGE

Part of the structure of the vehicle that prevents the driver from being crushed should the vehicle roll over onto its side or top. It is also known as a roll-over protective structure (ROPS).

Vehicles used on **public roads** usually have to comply with local laws (e.g. requirements for working headlights).

Vehicles used on **private land** (most workplaces) do not usually have to comply with the same public highway laws, but may have to meet specific legal standards relating to workplaces in general, or to a particular workplace (e.g. vehicles used in a quarry should always be fitted with a yellow beacon (flashing light) and that light should always be working when the vehicle is operational). A risk assessment may have to be completed to decide exactly which safety features are required of a vehicle in a particular workplace in order to meet legal standards.

TOPIC FOCUS

Pre-use checks should be carried out before use. Using the example of forklift trucks, the following should be checked at the beginning of each shift:

- Tyre pressure.
- Parking brakes and service brakes.
- Steering.
- Fuel, oil and water systems for leaks (in a combustion-engine truck).
- Batteries, to ensure they are charged and leak-free, with chargers off, leads stored and the battery retention device secured.
- Lifting and tilting systems (including hydraulics) are working, are leak-free and hydraulic fluid levels are correct.
- Audible warning.
- Lights.
- Mirrors.

Any defects should be reported to the supervisor for immediate rectification.

Safe Drivers

Since there are very few instances where automated vehicles can be used in a workplace, vehicles are usually under the control of a driver. It is essential that the driver is carefully selected, trained and supervised.

Drivers should be:

- **Competent to drive the vehicle**. Proof of qualification (e.g. driver's licence) may be necessary, or the driver may have to be trained and assessed to achieve qualification. Refresher training and re-certification may be required. In certain situations the driving licence may have to be checked periodically to ensure that the driver does not have undisclosed penalties or disqualification for road traffic offences.
- **Medically fit to drive**. A medical examination to assess the driver's health and fitness may be required. This should take place at selection and may have to be repeated periodically.
- **Provided with specific information, instruction and training** appropriate to the workplace and site where they will be driving. Driver-specific site induction training may have to be provided.
- **Supervised** to ensure that they follow safe systems of work, obey site rules and do not lapse into bad practices.

There are usually legal standards and local codes of practice relating to these matters.

Management systems should be in place to ensure driver competence. They should also be introduced as formal arrangements to the health and safety policy or local codes of practice.

Supervisor with forklift-truck driver

A **banksman** (also known as a reversing assistant) should be used to assist a driver with reversing and awkward manoeuvring operations where the driver cannot always fully see what they are in control of. A driver must always use their own judgement, and should only follow instructions from a properly trained banksman.

Banksmen may be used to ensure that vehicle manoeuvres in the vicinity of pedestrians are carried out safely.

MORE...

http://www.hse.gov.uk/PUBNS/books/hsg136.htm

REVISION QUESTIONS

1. What are the main types of hazard caused by vehicle operations?
2. What unsafe practices might cause a forklift truck to overturn?
3. What special equipment might be fitted to vehicles to protect drivers?
4. In what conditions should warning lights and alarm systems be used?
5. What are the main means of separating vehicles and pedestrians?

(Suggested Answers are at the end.)

Driving at Work

KEY INFORMATION

- Organisations should:
  - Establish clear policies on work-related driving safety.
  - Implement management systems and monitoring arrangements.
- Risk assessment of work-related driving should follow the standard five-step approach for risk assessment. Factors to consider include the distance travelled, driving hours, work schedules, stressful situations and weather conditions.
- Evaluation of risk should focus on three things: the driver, the vehicle and the journey.
- Control measures to reduce driving risk include:
  - Elimination of the need to travel.
  - Use of alternative means of transport.
  - The management of the risk factors associated with the driver, vehicle and journey.

In this section we look at the issue of driving a vehicle on the public highway for work - in particular, a company car. This section does not focus on large goods vehicles or passenger service vehicles, to which specific legislation often applies.

Driving on a public highway

MANAGING WORK-RELATED ROAD SAFETY

Managing work-related road safety requires the employer to integrate road safety into their existing safety management system. Road safety should be treated as simply another aspect of their general duty to ensure the health and safety of their staff and third parties. This requires the establishment of several management systems:

- **Policy** – an organisation's policy should cover work-related driving and should recognise that this activity puts a duty on the employer to manage the risk created. Specific arrangements must be made.
- **Responsibility** – there must be top-level commitment to the organisation's policy, and responsibility must be allocated at a senior level to ensure that the necessary authority and resources are available to back that commitment.
- **Organisation and structure** – work-related driving will often involve different groups of workers in different ways.

  An organisation's policy should be developed with those various groups in mind and often involves various interested parties from different parts of the organisation (e.g. training department, health and safety department, fleet managers); co-operation between these parties is therefore important.

- **Systems** – specific arrangements should be made to ensure that vehicles are maintained, inspected and tested in accordance with manufacturers' recommendations and appropriate legislation. Driver qualifications and fitness may have to be checked. These management systems must be established and reviewed periodically to ensure that they are still working adequately.
- **Monitoring** – various methods can be used to monitor the effectiveness of arrangements made and collect relevant information. For example, there should be a road traffic-accident reporting system, by which employees can report work-related road incidents.
- **Legal responsibilities** - individuals driving while at work are bound by the national laws governing road safety and road traffic offences. An individual in breach of these laws could face personal penalties, regardless of the fact that they were driving for work-related reasons. For example, a sales representative caught speeding would be personally liable for the offence, not the organisation. However, if offences were committed with the knowledge of the organisation, the company might also face legal action.

Accident report form

RISK ASSESSMENT

Work-related driving should be risk-assessed in the same way as other work-related activities. This will allow the employer to establish arrangements for controlling the risk. The standard five-step approach to risk assessment can be used:

1. **Identify the hazards** – these can be categorised according to the factors associated with driving that increase the risk of being involved in a road traffic incident, as outlined below.
2. **Identify the people who might be harmed** – this will include the driver, but may also include passengers and other road users. Certain groups might be more at risk, such as young drivers.

TOPIC FOCUS

Factors that affect the risk of being involved in a road traffic incident:

- Distance travelled – persons driving long distances are on the road longer and may drive for long periods without a break.
- Driving hours – it may be tempting to drive for a long period without a break in order to get to the destination faster, but this increases the risk of an accident due to fatigue and lapses of attention.
- Work schedules – poor planning and unreasonable work schedules (which do not allow adequate time between appointments) can cause drivers to speed, take risks, or fail to take breaks.
- Stress – heavy traffic conditions and road works can cause stress to drivers.
- Weather conditions – adverse weather conditions can increase the risk to those driving. For example:
  - Snow can cause the roads to be slippery and reduces visibility.
  - Fog affects visibility.
  - High winds are particularly hazardous to drivers of high-sided vehicles.

3. **Evaluate the risks** – the level of risk must be estimated and decisions made about appropriate control measures. A standard hierarchical approach can be adopted:
   - Eliminate the need to travel, e.g. conduct web-based video conference calls rather than meeting face-to-face.
   - Travel by a safer means of transport, e.g. train or aeroplane.
   - If travel by road is the only sensible option, ensure that the vehicle is appropriate and in a safe condition, and that an appropriate person is driving. Various arrangements can be made through the company policy to ensure that both the vehicle and the driver meet the required standards (see later).
4. **Record** findings and implement them.
5. **Review** – the risk assessment should be reviewed:
   - Following incidents.
   - After any significant changes.
   - Periodically.

EVALUATING THE RISKS

Evaluating the risks means looking at what controls are in place already – are they enough to reduce the risks to an acceptable level, or does more need to be done?

The risk evaluation should look particularly at:

- The **driver**.
- The **vehicle**.
- The **journey**.

The risk factors that might exist under each topic should be considered, as outlined above.

CONTROL MEASURES

Once the risks have been evaluated, appropriate control measures can then be identified for each risk factor. Some of these control measures require that specific management arrangements are put in place; others require that guidelines are prepared and passed on to drivers. In some instances, there may be clear statutory requirements that must be met. In many cases, however, the employer has to base their control measures on good practice.

The Driver

Three main risk factors exist for the driver:

- **Competency** – drivers should hold the relevant driving licence for the vehicle to be driven. They might also be required to demonstrate relevant experience, skill and knowledge:
  - Drivers' licences should be checked on recruitment and re-checked periodically (e.g. every six months) to ensure validity.
  - Some organisations set minimum standards regarding penalties recorded on company drivers' licences.
  - Management may take up references for proof of relevant experience and ability.
- **Training** – drivers may have to undertake specific training on safe driving:
  - An organisation may require drivers to undertake advanced driving or defensive driving training and assessments.
  - Training on vehicle safety may be provided for drivers, such as pre-use vehicle inspection, use of anti-lock braking, head restraint adjustment (to prevent whiplash injury), etc.
- **Fitness and health** – drivers may have to undergo a medical examination and be passed as fit to drive. For certain drivers this medical examination and certification is a legal requirement. In addition:
  - Medical examination is a matter of company policy for some organisations.
  - A driver's eyesight might need to be checked.
  - Drivers should be reminded about not driving while taking certain drugs that cause drowsiness.

The Vehicle

The following considerations are important in relation to the vehicle:

- **Suitability** – the vehicle must be suitable for its intended purpose:
  - Some organisations set a minimum requirement for the safety standards of the vehicle (as determined by the EuroNCAP crash test). Important safety features include: anti-lock braking, airbags, head rests and seat belts.
  - A personal vehicle should only be used for work if it has a valid regulatory certificate where required (e.g. MOT certificate in the UK, which checks certain roadworthy features of a vehicle of a certain age) and is insured for work use.
- **Condition** – the vehicle must be in a roadworthy condition, and:
  - Maintained in accordance with the manufacturer's recommended service schedule.
  - Routinely inspected prior to use to check the condition of tyres, lights, etc.
  - Defects should be reported and corrected where they are safety-critical.

Vehicle testing and maintenance

- **Safety equipment** – the vehicle should carry suitable safety equipment:
  - Seat belts, airbags and head restraints are fitted as standard in many vehicles – they should be in good order.
  - Other safety equipment may be specified by the employer, such as emergency triangles, first-aid kit, spare tyre and fire extinguisher.
- **Safety-critical information** – certain information must be understood by the driver. Examples of safety-critical information that the driver should know include:
  - Tyre pressure.
  - Headlight adjustment.
  - Head restraint adjustments.
- **Ergonomic considerations** – the adjustability of the seat position and vehicle controls, as well as driver posture, should be considered when selecting vehicles to ensure driver comfort and to minimise the risk of back pain and other musculoskeletal disorders (MSDs).

The Journey

There are also several considerations relating to the journey that need to be taken into account when determining control measures:

- **Routes** – route planning allows for hazards to be avoided and risks minimised:
  - Busy areas (e.g. town centres) or high-risk areas (e.g. accident black-spots) can be avoided.
  - Low-risk roads can be selected; motorways and dual carriageways (also known as divided highways) are the safest roads.

Roadworks

  - Road works can be avoided.
- **Scheduling** – scheduling journeys at the right time of day:
  - Avoiding travel at peak traffic times.
  - Avoiding travel at times when drivers will feel naturally fatigued (02.00 – 06.00 and 14.00 – 16.00).
  - Allowing flexibility of deadlines.
- **Time** – allowing sufficient time for the journey:
  - Time allowed must be realistic given the route chosen, weather conditions and anticipated breaks.
  - Unrealistic deadlines put pressure on drivers to speed.
  - Rest breaks must be factored into journey times: a 15-minute break every two hours is recommended.
  - There are statutory requirements for professional drivers.
- **Distance** – travel distances must be reasonable:
  - It may be possible to minimise travel distances by using other forms of transport for some of the journey.
  - Distance must not be excessive, and consideration should be given to the length of the driver's day outside of the driving time.
- **Weather conditions** – weather forecasts and adverse weather conditions must be taken into account when journey planning and travelling. Drivers should:
  - Have access to reliable weather forecast information so that they can plan their journey accordingly.
  - Be given guidance on adverse weather conditions when they should not travel.
  - Be trained in additional safety measures to deal with adverse weather conditions.

MORE...

The following websites contain lots of useful information about driving safely for work:

http://www.hse.gov.uk/roadsafety/index.htm

http://www.drivingforbetterbusiness.com/

REVISION QUESTIONS

6. What is the first option to consider when controlling driving risk?
7. What are the three main areas of concern that can be managed by the risk assessment process?
8. Give three risk factors associated with the journey.

(Suggested Answers are at the end.)

SUMMARY

This element has dealt with the movement of vehicles in the workplace and driving at work.

In particular this element has:

- Identified the hazards presented by vehicle operations and categorised them as:
  - Hazards relating to vehicle movement, which include driving too fast, reversing, silent operation of machinery and poor visibility.
  - Non-movement-related hazards, including loading, unloading and securing loads, coupling, maintenance, etc.
- Identified the typical risks associated with movement vehicles, which include vehicle overturn, and collisions with pedestrians, other vehicles or fixed structures.
- Explained how the use of control measures can ensure safe workplace transport operations, through the risk assessment process and by careful management of the workplace environment, vehicles and drivers.
- Outlined how safe sites (i.e. workplace environments) should be designed, constructed and maintained to allow safe vehicle movement and to separate vehicles from pedestrians.
- Identified key requirements for safe vehicles; among other requirements, they must be suitable for their intended use and workplace environment, and maintained in safe working order.
- Noted some key requirements for safe drivers; they must be appropriately qualified, medically fit and given appropriate information, instruction, training and supervision.
- Outlined the relatively high-risk nature of work-related driving on the roads, as well as the need for organisations to establish clear policies on work-related driving safety and to implement management systems and monitoring arrangements.
- Explained how the risk assessment of work-related driving should focus on three main areas of concern: the driver, the vehicle and the journey, each of which has various risk factors associated with it.
- Described the control measures available to reduce driving risk, such as the elimination of the need to travel, use of alternative means of transport and the management of the various risk factors associated with the driver, vehicle and journey.

QUESTION

(a) **Identify THREE** control measures to segregate pedestrians and vehicles in the workplace. (3)

(b) **Identify** measures to reduce the risk to pedestrians when segregation is not practicable. (5)

IGC2 March 2010, Question 2

APPROACHING THE QUESTION

Think now about the steps you would take to answer the question:

1. The first step is to read the question carefully. You are asked to identify measures, which means that you can "give without explanation". Your answers should therefore be quite succinct.

2. Next, consider the marks available. In this question there are eight marks, three for part (a) and five for part (b). Multi-part questions are often easier to answer because there are additional signposts in the wording of the question to keep you on track. In part (a) you have been specifically asked for three control measures – if you provide any more they won't be marked. However, in part (b) there is no such restriction. It would be logical to conclude that NEBOSH expect five control measures for part (b), as there are five marks available. However, in this case if you can think of a couple of additional measures, it would increase your likelihood of gaining full marks. The question should take around eight minutes in total.

3. Now highlight the key words. In this case they might look like this:

   (a) **Identify THREE** control measures to segregate pedestrians and vehicles in the workplace.
   (3)

   (b) **Identify** measures to reduce the risk to pedestrians when segregation is not practicable.
   (5)

4. Read the question again to make sure you understand it and have a clear understanding of controls to protect pedestrians. (Re-read your notes if you need to.)

5. The next stage is to develop a plan – there are various ways to do this. Your answer must be based on the key words you have highlighted. Remind yourself, first of all, that you need to be thinking about "How are pedestrians kept separate from vehicles?" and then "How else can we ensure the safety of pedestrians?"

Now have a go at the question. Draw up an answer plan, and then use it as the basis to write out an answer as you would in the exam.

Take care to keep an eye on the time when answering – it is very easy to spend too long on a question, and there are only eight marks available, no matter how long you spend on it!

When you have finished, compare your plan and full answer with those provided.

SUGGESTED ANSWER

Plan

Pedestrian/Vehicle Segregation

- Prevent access to pedestrians altogether.
- Barriers around walkways.
- Painted/designated walkways and footpaths.
- Separate doorways for pedestrians.
- Site rules to ensure walkways are followed.
- Training.

Other Pedestrian/Vehicle Controls

- Good lighting.
- Pedestrian crossing points, e.g. zebra crossing.
- Pedestrian refuge areas.
- Lights and alarms on vehicles.
- Use of a banksman when reversing.
- Trained drivers.
- Speed-limited vehicles.
- Mirrors to reduce blind spots.
- High-visibility clothing.
- Signs to warn of vehicle operations.

POSSIBLE ANSWER BY EXAM CANDIDATE

(a) Control measures to segregate pedestrians and vehicles include:

- *The provision of barriers to restrict access to areas where vehicles are in use (perhaps excluding pedestrians altogether from an area with high vehicle activity).*
- *The provision of designated walkways for use by pedestrians, which are clearly marked.*
- *The enforcing of site rules restricting pedestrians to the walkways when moving around the site.*

(b) Control measures to protect pedestrians when segregation is not practicable include:

- *Provision of pedestrian crossings, e.g. zebra-crossing points.*
- *Use of flashing beacons on vehicles.*
- *Use of audible reversing alarms on vehicles to warn of reversing operations.*
- *Use of banksmen (reversing assistants) when reversing to ensure pedestrians are not present when vehicles are moving.*
- *Use of trained drivers, e.g. with forklift trucks.*
- *Use of restricted vehicles which operate at reduced speeds, or if not possible speed limits which are enforced.*
- *Ensuring good visibility, with good lighting and mirrors to minimise blind spots.*

REASONS FOR POOR MARKS ACHIEVED BY CANDIDATES IN EXAM

Most candidates found this question straightforward, although there was some confusion between what was being asked for in part (a) and part (b). Part (a) asked for methods of **segregation** whereas part (b) asked for controls if **segregation is not practicable**.

You will see in the example answer provided above that bullet points were used to structure the answer. Although we warn against producing a bullet-pointed "list" in an exam answer, bullets **can** be used to good effect to help show the examiner where each new point is. What you must avoid at all costs is a bullet-pointed list of "words" – this will not give the examiner enough detail. What you can see here is a series of controls that are in the appropriate depth to be considered as "identify". Compare this with the following, which would not be acceptable:

- Banksmen.
- Alarms.
- Training.
- Hi-vis.
- Zebra crossings.

This would **not** be acceptable – there is insufficient depth to meet the question requirements and so the marks would not be awarded. So **don't** simply list words, but bullet points themselves are not prohibited, if they are used correctly.

MUSCULOSKELETAL HAZARDS AND RISK CONTROL

ELEMENT 3

LEARNING OUTCOMES

On completion of this element, you should be able to demonstrate understanding of the content by applying what you have learnt to familiar and unfamiliar situations. In particular, you should be able to:

1. Explain work processes and practices that may give rise to work-related upper limb disorders, and the appropriate control measures.
2. Explain the hazards and control measures that should be considered when assessing risks from manual-handling activities.
3. Explain the hazards, precautions and procedures to reduce risk in the use of lifting and moving equipment, with specific reference to manually-operated load-moving equipment.
4. Explain the hazards and the precautions and procedures to reduce risk in the use of lifting and moving equipment, with specific reference to powered load-handling equipment.

Contents

Work-Related Upper Limb Disorders

KEY INFORMATION

- Musculoskeletal disorders, such as back pain and work-related upper limb disorders (WRULDs), can result from repetitive tasks, such as display screen equipment (DSE) use, checkout operation and bricklaying.
- Many factors influence ergonomic risk, such as repetition, force, posture, twisting, rest breaks, equipment design and adjustability, and workplace lighting.
- DSE use can cause WRULDs, back pain and eye strain.
- Precautions for safe use of DSE include: ergonomic assessment of the workstation; provision of basic equipment; short, frequent breaks; eye tests; and the provision of information and training.

MUSCULOSKELETAL DISORDERS AND WORK-RELATED UPPER LIMB DISORDERS

Various ill-health effects will occur if a workplace has been poorly designed, tasks are being carried out badly, the environment is poor, or tools and equipment are poorly selected and used. The specific ill-health effect will depend on the work and the individuals concerned, but typical forms of ill-health associated with poor work design are:

- **Back injuries and back pain** – associated with repetitive handling or poor posture and movement while standing or sitting for long periods of time. Injuries such as back muscle strain, ligament strain and disc injury are common; these injuries are a significant cause of workplace absence.
- **Work-related upper limb disorders (WRULDs)** – a generic term for many different medical conditions that affect the arms and hands. WRULDs usually involve inflammation and discomfort through overuse of muscles, tendons or ligaments and frequently there is irritation to the nerves, which causes additional pain.

  WRULDs usually start as tingling sensations, numbness and minor discomfort, gradually worsening to severe pain and immobility. They can lead to corrective surgery – and even disability – if left untreated. Examples include carpal tunnel syndrome (inflammation of a nerve in the wrist that causes tingling sensations, pins and needles, numbness in the fingers and arm pain), tennis elbow and tenosynovitis (inflammation of the tendons in the forearm that makes finger movement difficult and painful). These conditions are also sometimes referred to as repetitive strain injuries (RSI).
- **Other chronic soft-tissue injuries** – associated with sitting, standing or kneeling for long periods of time at work, e.g. painful knee joints as a result of having to kneel down to work under floorboards.

Collectively, all these conditions can be referred to as **musculoskeletal disorders** (MSDs).

HIGH-RISK ACTIVITIES (REPETITIVE OPERATIONS)

The following repetitive activities all involve significant risk of musculoskeletal disorders:

- Display screen equipment (DSE) use, in particular keyboard operation (see later for more detailed information on the assessment of DSE workstations and appropriate control measures).
- Factory assembly of small components.
- Bricklaying.
- Supermarket checkout operation.

MATCHING THE WORKPLACE TO INDIVIDUAL NEEDS

The risk of musculoskeletal disorders can be reduced by matching the workplace to suit the individual needs of workers. This is often referred to as applying an **ergonomic** approach.

GLOSSARY

ERGONOMICS

The study of the relationship between the worker, the work that they are doing, and the environment in which they are doing it.

Ergonomics is concerned with the interaction between people and:

- The tools, equipment or machinery that they are using (e.g. the ease of use of control panels).
- The workplace environment (e.g. suitability of lighting).
- Organisational factors (e.g. shift patterns, hours of work).

Work-Related Upper Limb Disorders

The aim of ergonomics is to minimise ill-health effects and optimise efficiency by matching the workplace to the needs of the individual. This means taking into account both a person's physical attributes (such as height, shape, muscle strength, etc.) and their mental attributes (processing speed, decision-making ability, etc.). For example, ergonomic principles can be applied to a manual-handling operation to reduce the risk of injury.

THE ILL-HEALTH EFFECTS OF POOR TASK AND WORKSTATION DESIGN

The ill-health effects of poorly designed tasks and workstations include:

- Fatigue or strain on the eyes from excessive glare, poor lighting, screen flicker, etc.
- Headaches from excessive glare, noise or poor lighting.
- General fatigue due to temperature difference (either too high or low), humidity, monotony, poorly placed controls, or difficult-to-read displays.
- Aches, pains and muscle strains from being required to make movements such as over-reaching, continually getting up and down, turning, twisting, etc. Poor positioning of keyboards and display screens can contribute to this.
- Aches and pains from poor seating design and positioning in relation to workstation items and tasks.

MSD RISK FACTORS

Various factors influence the risk of musculoskeletal disorders from work activities. These relate to the **task** the worker is doing, the **equipment** they are using, and the **environment** they are working in. These factors can be applied to any repetitive work activity, whether it is working on a factory assembly line, or bricklaying on a construction site.

An uncomfortable static posture leads to musculoskeletal disorders such as neck pain and knee pain

TOPIC FOCUS

ERGONOMIC FACTORS INFLUENCING RISK

Task factors:

- **Repetition** – the need for repetitive movements when carrying out the task (e.g. typing for several hours).
- **Force** – the (strenuous) physical force required to perform the task and the strain this puts on the body (e.g. closing stiff catches on a machine).
- **Posture** – any requirement to adopt an awkward posture (e.g. stooping over into a bin to pick out contents).
- **Twisting** – any twisting action required by the task (e.g. twisting the wrist when using a screwdriver).
- **Rest** – the potential for the worker to rest and recover from any fatigue (e.g. a worker on a production line cannot stop the line; they have to keep working even when fatigued).

Environment factors:

- **Lighting** – the availability of natural and artificial light and the effect on the worker's ability to see the work clearly. The presence of glare may also cause a problem.
- **Other environmental parameters** – in particular temperature, humidity and ventilation will directly affect the worker's ability to perform the task and their comfort.

Equipment factors:

- **Equipment design** – the shape of the equipment and how this affects ease of use (e.g. a large, shaped handle on a scraper makes it easier to hold and use).
- **Equipment adjustability** – the scope available for the user to adjust the equipment to suit their personal requirements (e.g. the height of the seat for a computer user).

If one or more of the above factors is inherent in the work, then ergonomic risk exists.

APPROPRIATE CONTROL MEASURES

Many activities involve significant ergonomic risk. For example, bricklaying on a construction site involves several of the risk factors noted above: the work is repetitive; awkward posture and twisting is necessary; rest periods may be infrequent; and the work area may be extremely cold and windy, or hot, humid and airless.

In general terms, the control of ergonomic risk can be achieved by introducing changes to:

- the **task** and the way that it is done;
- the **tools**, **equipment** and **machinery**; and
- the **workplace environment**

to suit the individuals carrying out the work.

In some cases, it may be appropriate to put restrictions on the individuals doing the work (i.e. restricting those people who have a known WRULD to light duties in order to avoid further injury). The first step in achieving controls is to undertake a risk assessment.

The following two examples (use of display screen equipment and work on a factory assembly line) illustrate the ill-health effects that can result from ergonomic risks and the possible control measures that may be implemented.

Display Screen Equipment

Risks

Use of display screen equipment (DSE) or computers and keyboards is a common workplace activity that has several associated ill-health issues:

- **WRULDs** – associated with repetitive use of the keyboard and mouse for long periods of time.
- **Eye strain** – temporary eye fatigue associated with prolonged use of the screen.
- **Back pain** and other MSDs – associated with sitting in a fixed position, perhaps with poor posture, for long periods of time.
- **Fatigue and stress** – associated with the type of work being done, e.g. call-centre staff may be subjected to verbal abuse during telephone calls.

These health effects can occur when using desktop computers but are becoming increasingly common in association with the use of laptops when they are used for long-duration work.

The portability of laptops allows them to be used in a casual manner that is inappropriate for long-duration use

Control Measures

Control measures appropriate for DSE use:

- Carry out an assessment of the user's workstation to ensure that:
  - The equipment and environment meet minimum standards.
  - The workstation can be adjusted to suit the user.
- Provide basic DSE workstation equipment that meets minimum standards in terms of good ergonomic design.
- Plan the user's work routine so that they can take short, frequent breaks from screen and keyboard use.
- Provide DSE users with a free eye test and, if required, spectacles for screen use.
- Provide information and training to users on the potential health risks of DSE use and the preventive measures, in particular ergonomic use of the workstation.

These measures are often incorporated into legal standards and codes of practice (e.g. EU regulations make the control measures listed above statutory).

Some of the minimum standards for workstation equipment and the good practices related to posture and workstation use are illustrated in the following figure.

Work-Related Upper Limb Disorders

Good ergonomics at a DSE workstation

The numbered issues are as follows:

1. Adjustable height and angle to seat back.
2. Good lumbar support.
3. Adjustable seat height to bring the hands to a comfortable position on the keyboard. Seat also has a stable five-star base.
4. Correct seat-height adjustment and keeping the feet supported prevents excess pressure on underside of thighs and backs of knees.
5. Foot support if user cannot get their feet on the floor.
6. Space for postural change, no obstacles under desk; this allows the user to fidget and change position as they work.
7. Forearms approximately horizontal when hands are on keyboard.
8. Minimal extension, flexion or deviation of wrists; wrists should be straight and flat when on the keyboard, indicating proper seat-height adjustment.
9. Screen height and tilt should be adjustable to allow comfortable head position.
10. Space in front of keyboard to support hands/wrists during pauses in keying; a wrist-rest can provide further support, if required.

In addition to these points:

- The desk should be laid out to minimise the need for twisting or overreaching (e.g. when reaching for a telephone).
- A document holder may be required.
- If frequent telephone use is necessary when using the keyboard, a headset may be required.
- Workplace lighting should be provided to avoid reflections on the screen and glare.

Unfortunately, some of these good ergonomic principles cannot be applied to use of a laptop computer. If laptops are going to be used in the workplace then:

- Allow short-duration use but not long-duration use.
- When laptops are going to be used for long durations apply the same management approach of workstation assessment, frequent breaks, eye test, information and training.
- Provide a docking station and/or separate screen, keyboard and mouse, as required, to allow the user to convert the laptop to a more adjustable configuration.

Factory Assembly Line

Risks

Assembling small components on a factory production line will have many of the same health effects as DSE use:

- **WRULDs** – associated with repetitive handling of parts for long periods of time.
- **Eye strain** – temporary eye fatigue associated with having to focus on small parts.
- **Back pain** and other MSDs – associated with sitting or standing in a fixed position for long periods of time, perhaps in association with overreaching, twisting and stooping to reach parts.
- **Fatigue and stress** – associated with infrequent rest breaks and a demanding work-rate.

Control Measures

The control measures appropriate for the factory assembly line are very similar to those applied in the case of DSE use:

- Carry out an ergonomic assessment of the workstation to ensure that it is appropriate and can be adjusted to suit the worker's needs.
- Plan the worker's work routine so that they can take recovery breaks.
- Provide information and training to workers on the potential MSD health risks and the preventive measures - in particular, ergonomic use of the workstation.

Specific controls might include:

- Automating the process to eliminate the MSD risk entirely.
- Changing the layout of the workstation to allow comfortable posture and to minimise overreaching, stooping, twisting, etc.
- Providing seating (if it is not already available).
- Providing comfortable shoes and floor mats to relieve foot pressure if sitting is not possible.
- Allowing short, frequent breaks from the production line, or introducing job rotation to avoid long periods spent on one task.
- Ensuring lighting is appropriate to the task (brightness or lux levels should be relatively high for fine detail work).
- Introducing ergonomically-designed hand tools.

MORE...

The European Agency for Safety and Health at work provides information about musculoskeletal disorders in the workplace:

http://osha.europa.eu/en/topics/msds

REVISION QUESTIONS

1. Sum up the aims of ergonomics in a simple phrase.
2. What are the categories of health risks arising from poor task and workstation design?
3. Give the risk factors involved in the physical requirements of the task.
4. Summarise the key requirements relating to the following parts of a DSE workstation:

   (a) Work surface/desk.

   (b) Keyboard.

   (c) Chair.

   (d) Space.

(Suggested Answers are at the end.)

Manual-Handling Hazards, Risks and Control Measures

KEY INFORMATION

- Manual handling is a common cause of musculoskeletal injuries, such as:
  - Injuries to the back, tendons, ligaments and muscles.
  - Work-related upper limb disorders (WRULDs).
- Manual handling can be assessed by looking at four main factors: the task; the load; the environment; and individual capabilities.
- The risk associated with manual handling can be controlled by:
  - Automating or mechanising the handling to eliminate the manual handling.
  - Assessing manual handling that cannot be eliminated.
  - Using handling aids.
  - Modifying the task, load or environment.
  - Ensuring individual capabilities are matched to the activity.
- Safe lifting technique involves following simple precautions before the lift, during the lift, and when setting down.

COMMON TYPES OF MANUAL-HANDLING INJURY

Manual handling is an activity that takes place in most workplaces. Often, manual handling is a routine part of day-to-day work activity: workers on a construction site frequently move building materials by hand; factory workers routinely pack boxes by hand; farm labourers spend hours at a time bent double in the fields picking crops. In some workplaces manual handling occurs infrequently; office workers do not often have to lift or carry loads on a daily basis, but they will do so occasionally.

Manual handling sometimes involves very repetitive movements of relatively small loads (e.g. handling small components on a production line); in other instances, it can involve one-off movements of very large and heavy items (e.g. handling structural steels into position in an inaccessible location).

GLOSSARY

MANUAL HANDLING

The lifting, carrying, pushing and pulling of a load by bodily force.

All these manual-handling activities generate the possibility of injuries, most of which are musculoskeletal injuries. Common types of manual-handling injury include:

- **Back injury** – the spine is made up of individual bones (vertebrae) separated by tough pads (intervertebral discs). Wear and tear can occur to these discs so that they become distorted (slipped disc). This causes extreme pain and discomfort and is often accompanied by nerve pain because the distorted disc traps nerves where they enter the spinal cord. This type of injury is perhaps the most serious of all manual-handling injuries since recovery is often slow and incomplete; in some instances, the victim will have to undergo surgery to repair the defect, or may end up permanently disabled.

Worker with back injury

- **Tendon and ligament injuries** – (tendons and ligaments are the connective tissues that join muscle to bone, and bone to bone, respectively). When tendons and ligaments are overloaded they tear, causing extremely painful injuries that can take a long time to heal. In some instances, recovery is incomplete and an operation may be required.
- **Muscle injuries** – overloaded muscle tissue can tear. This is painful and likely to lead to short-term impairment.
- **Hernias** – when the sheet muscle that surrounds the gut is overloaded it can distort and tear. This usually happens in the lower abdomen and can be a painful injury that will not repair naturally. In many instances, an operation is required.
- **Work-related upper limb disorders** (**WRULDs**) – chronic soft-tissue injuries to the arms, wrists and hands as a result of repetitive movements (also referred to as repetitive strain injuries (RSI)).

  As described earlier, WRULD is a generic term for many different medical conditions, such as carpal tunnel syndrome and tennis elbow. WRULDs usually involve inflammation and discomfort through overuse of muscles, tendons or ligaments and frequently there is irritation to the nerves, which causes additional pain. WRULDs usually start as minor discomfort that gradually worsens to severe pain and immobility. They can result in corrective surgery, and even disability, if left untreated.
- **Cuts, burns, dislocation and broken bones** – physical injury may result if the load is hot, sharp, or dropped on the feet.

ASSESSING MANUAL-HANDLING RISKS

When a manual-handling activity cannot be completely eliminated then it must be assessed. This risk assessment will be slightly different from the general risk assessment you are already familiar with because it focuses exclusively on the hazard of manual handling and ignores all other hazards.

Manual-handling risk assessment focuses on four main factors:

- The task.
- The load.
- The environment.
- Individual capabilities.

HINTS AND TIPS

An easy way to remember the factors in a manual-handling risk assessment is by using the acronym TILE – Task, Individual, Load and Environment.

The Task

The focus here is on the movements required of the worker as they handle the load.

The **task** can be assessed by asking questions such as:

- At what height is the load being picked up, carried or put down?
- Is the task very repetitive?
- Is there a high work-rate?
- Is a long carrying distance involved?
- Can rest breaks be taken as the worker requires them?
- Does the task involve:
  - Stooping (where the worker has to keep their legs straight and bend their back) to move the load?
  - Twisting (turning the shoulders while the feet stay still)?
  - Lifting the load through a vertical distance?
  - Reaching above shoulder height?
  - The worker holding the load away from their trunk (torso)?

Each of these risk factors increases the risk associated with the task. For example, picking up a load at waist height, carrying it a short distance and putting it down at waist height is a simple task that does not complicate the risk associated with the handling. But picking up the same load from floor height from the bottom of a box, which requires the worker to stoop down into the box (risk factor 1), then carrying the load at arms' length (risk factor 5) for a distance of 15 metres (risk factor 3) and putting it down above head height (risk factor 4) increases the risk associated with the task very significantly.

Holding a load away from your torso when lifting increases risk of injury

Manual-Handling Hazards, Risks and Control Measures

The Load

Here, the focus is on the load that is being handled.

Though the load is usually an inanimate object, in some workplaces it may be an animal or a person, e.g. in a hospital, patients have to be moved from bed to gurney (a wheeled stretcher/trolley), from wheelchair to bath, etc.

The **load** can be assessed by asking questions such as:

- How heavy is the load?
- How large and bulky is the load?
- Is the load an easy shape to lift?
- How stable is the load?
- Where is the centre of gravity (C of G) of the load?
- Is the load difficult to grip? (Or does it have handles?)
- Is the load hot, sharp or otherwise hazardous?

For example, the risk associated with handling a 12kg concrete block is lower than that associated with handling a bundle of flexible plastic pipes, each three metres long, that weighs the same in total.

How stable is this load?

The Environment

The focus here is on the environment in which the handling takes place.

The **environment** can be assessed by asking questions such as:

- Are there restrictions on the space available?
- Is the floor surface slippery or uneven?
- Are there changes in floor level (steps, stairs, etc.)?
- What are the light levels like?
- What is the temperature and humidity?

For example, handling activities carried out outdoors on a poorly-lit construction site in freezing conditions when there is ice on the ground will be higher risk than similar activities carried out indoors in a warm, well-lit area.

Individual Capabilities

The focus here is on the **worker** carrying out the handling activity.

Individual capabilities can be assessed by asking questions such as:

- Does the activity require unusual ability? Some handling activities require unusual strength, stamina, size or technique.
- Does the activity present significant risk to vulnerable individuals, such as pregnant women or people with pre-existing back injuries?

AVOIDING OR MINIMISING MANUAL-HANDLING RISKS

Control of manual-handling risk can be achieved by using a simple hierarchy of controls:

- **Eliminate the manual handling** – by automation or mechanisation of the handling activity. Conveyor belt systems, forklift trucks, electric pallet trucks, cranes, hoists and other types of mechanical moving or lifting equipment provide ways of moving loads without the need for workers to use bodily force.

Electric hoist moving load

- **Assess manual handling that cannot be eliminated** – by looking at the four factors of: task, load, environment, and individual capabilities.
- **Use handling aids** – consider using a piece of equipment that does not completely eliminate the manual handling but does make it much easier. For example, a sack truck does not eliminate the need to push the load, but it does eliminate the need to carry it.

  There are many handling aids available, such as trolleys, barrel lifts, gin wheels, trucks, hoists and lifts – these require some manual effort to lift or support the load, but give the worker a mechanical advantage.

Trolleys are a form of handling aid

- **Modify the task, load or environment** – when the appropriate questions listed earlier are answered, there are usually some simple solutions that present themselves.

  Modifications may be possible to reduce the significant risk factors, such as:

  The **task**:

  – Control repetitive handling by introducing frequent rest breaks or job rotation to minimise the length of time that an individual worker has to perform the task.
  – Eliminate stooping and twisting by changing the layout of the workstation.
  – Use a table or lift to bring the load to waist height to eliminate picking up from floor level.

  The **load:**

  – Break down a heavy load into smaller parts.
  – Use several workers to handle a large, bulky load rather than just one.
  – Stabilise an unstable load by securing it, or putting it into a container.
  – Mark up a load with an off-centre C of G so that workers can see where the C of G is.
  – Attach handles to a load that is difficult to grasp.

  The **environment**:

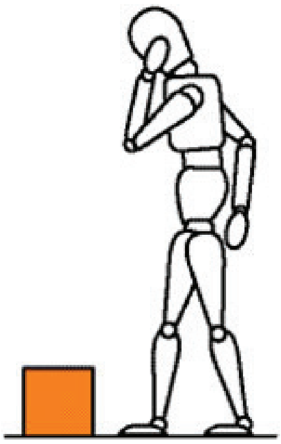
  – Rearrange the workspace to allow more space for the handling activity.
  – Level an uneven floor.
  – Supply additional lighting in a poorly-lit location.

- **Ensure individual capabilities are matched to the activity** – if the activity requires unusual ability then workers must have that ability. For example, if unusual strength and size are required then the worker must have those characteristics. If a particular technique is required then the worker must be trained so that they develop that technique.
  If the activity presents significant risk to vulnerable individuals, such as pregnant women or people with pre-existing back injuries, then those people will have to be prohibited from carrying out the activity.

EFFICIENT MOVEMENT PRINCIPLES

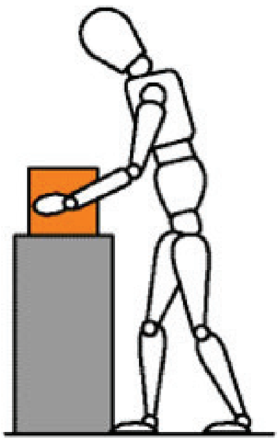
Employees should be trained in efficient movement principles that incorporate basic safe lifting techniques. This technique minimises the risk of musculoskeletal disorders and consists of the following steps:

- **Before lifting:**
  - Check the weight, C of G and stability of the load.
  - Plan the route of the carry.
  - Establish a firm grip.



- **The lift:**
  - Bend the knees and use the leg muscles to lift.
  - Keep the back upright.
  - Keep the load close to the body.
  - Avoid twisting, over-reaching, jerking.

- **Setting down:**
  - Use the same principles as when lifting.
  - Maintain good balance.
  - Set the load down and then adjust its position using body weight.



MORE...

The UK Health and Safety Executive (HSE) provides information on musculoskeletal disorders and manual handling:

http://www.hse.gov.uk/msd/index.htm

REVISION QUESTIONS

5. What are the main injuries associated with manual handling?
6. What is a WRULD and how might it occur?
7. What are the characteristics of the load that may present a hazard?
8. Identify the main risk factors presented by the working environment in relation to manual handling.
9. What is the primary means of minimising the hazards of manual handling?
10. What sort of individual might be more prone to manual-handling injury?

(Suggested Answers are at the end.)

Manually-Operated and Powered Load-Handling Equipment

KEY INFORMATION

- There are many different types of lifting and moving equipment, including:
  - Manually-operated trucks and hoists.
  - Powered equipment such as forklift trucks, lifts, hoists, conveyors and cranes.
- Typical hazards associated with lifting and moving equipment are:
  - Collapse or toppling of the equipment.
  - Falls from height.
  - Falling objects.
  - Being struck by the equipment or the load during movement.
- General precautions for safe use include ensuring that the equipment is:
  - Suitable in terms of strength and stability.
  - Correctly positioned and installed.
  - Visibly marked with the safe working load.
  - Used by competent operators under appropriate competent supervision.
  - Maintained in a safe working condition.
  - Only used for carrying people if it has been designed for that purpose and all additional safety requirements have been implemented.
- Lifting equipment should be routinely inspected and subjected to a statutory thorough examination by a competent engineer, as required by local law.

Loads are frequently moved around the workplace using lifting and moving equipment. This equipment may rely on some form of **manual effort** (such as a trolley, sack truck, or pallet truck) or it may be **powered** (such as a forklift truck, hoist, conveyor, or crane). Though these devices are useful in minimising the risks associated with manual handling, they do present their own hazards. The hazards and safety precautions of various types of lifting and moving equipment now follow.

HAZARDS AND CONTROLS FOR MANUALLY-OPERATED LOAD-HANDLING EQUIPMENT

There are many different types of manually operated load handling aids and equipment, such as trolleys, sack trucks and pallet trucks. The **hazards** associated with this type of equipment include:

- Manual-handling risk associated with pushing or pulling the truck.
- Instability of the load causing the load to fall.
- Moving up, down or across slopes, causing loss of control.
- Poor parking of the truck, causing obstruction in a traffic route.
- Other pedestrians may be struck during manoeuvring.
- Trapped feet under the wheels, or when lowering the load.

Precautions for safe use of manually-operated equipment include:

- Avoidance of uneven ground and slopes.
- Use of ramps over steps.
- Observing the safe working load limits of the truck.
- Securing the load if necessary.
- Using the brakes (if fitted) whenever the truck is stationary.
- Care when moving or lowering the load.
- Safe parking and storage to avoid obstruction.
- Routine inspection and maintenance.
- Use of safety shoes or boots to avoid crush injuries.

Lifts and Hoists

A wide variety of items can be included in the phrase "lifts and hoists." These range from a simple manually-operated chain hoist to a passenger lift in a multi-storey building; we will look at larger hoists later in this element.

People Hoists and Handling Aids

In some sectors workers may have to move people, such as hospital patients and those needing assistance with living requirements in the home. There is a variety of moving and handling aids available, including:

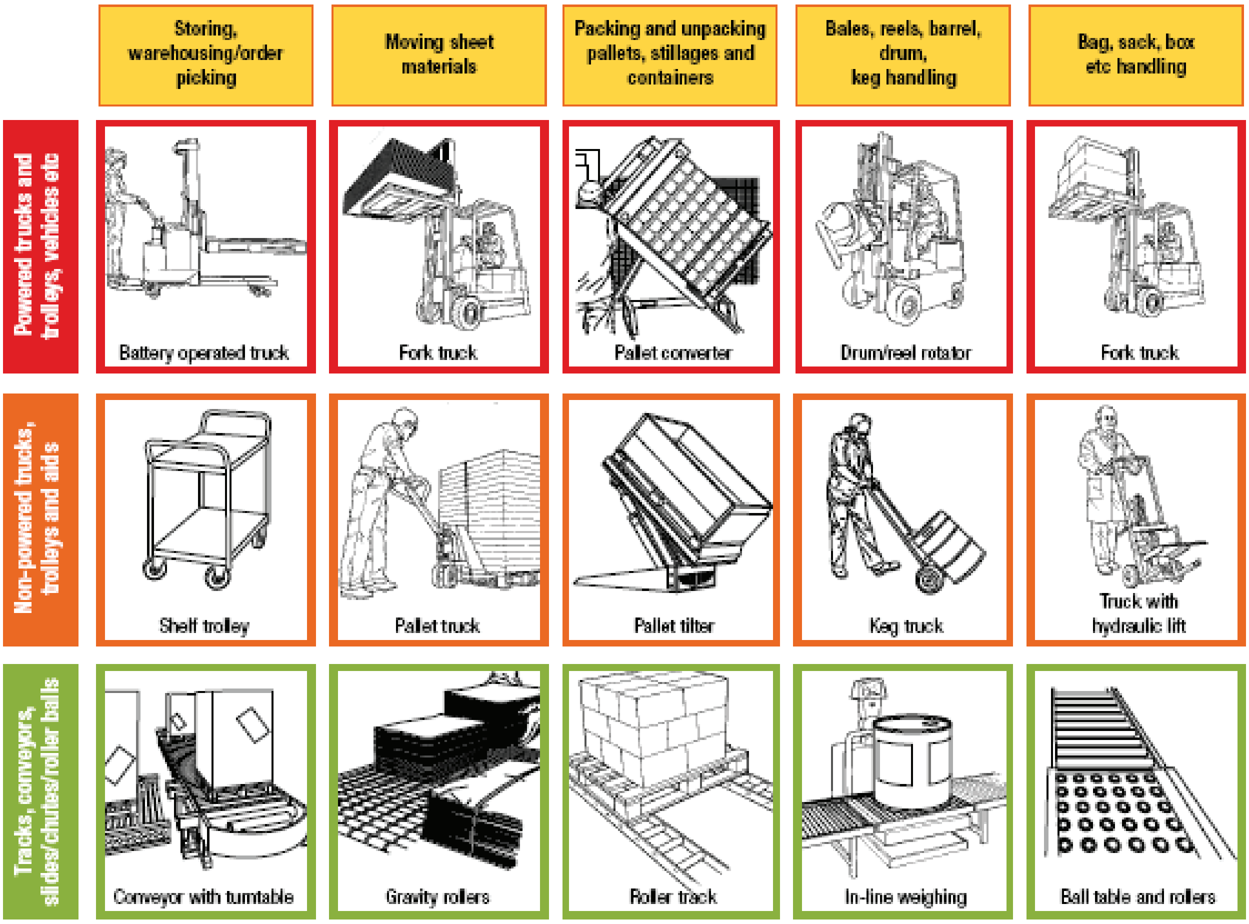
- **Patient hoists** – these can be manual (where the hoist is lifted by operating a manual crank handle) or powered, and may be mobile or permanently mounted in a ceiling track. Hoists should only be used by trained personnel and the safe working load of the hoist should not be exceeded. The suitability of the equipment for the working environment must also be considered, e.g. pushing a mobile hoist on a carpet or over rugs may be difficult. Lifting equipment of this type should be inspected regularly to ensure it remains in good working order.

A manual, mobile hoist used to lift patients

- **Small handling aids** such as slide sheets and transfer boards – used to assist the transfer of patients, e.g. from bed to trolley in a hospital. The slide sheet is placed beneath the patient and the person is pulled over the slide onto the bed. This allows for the rapid transfer of the patient without lifting them and is again for use by trained persons.
- **Wheelchairs** – a form of handling aid, wheelchairs help in the movement of people. Though they can be powered, most wheelchairs used to transfer patients are simply pushed.

To make sure that workers are competent to use mobility assistance equipment, training in handling techniques should include instruction in the:

- Different types of equipment available and their appropriate use.
- Safe use of hoists and their slings.
- Recharging of electric hoists.
- Safe use of the smaller aids, such as handling belts, and transfer boards.
- Identification of possible faults and safety checks that should be made each time before use.
- Procedures to follow when equipment is damaged and unsafe to use, or if it fails during use.



Summary of handling options available, including both powered and manually-operated equipment
(Source: INDG398(rev1) Making the best use of lifting and handling aids, HSE, 2013 - http://www.hse.gov.uk/pubns/indg398.pdf)

POWERED LOAD-HANDLING EQUIPMENT

TOPIC FOCUS

There are several general requirements for safe lifting operations:

- The equipment should be strong enough for the lifting task (rated for the load to be lifted) and suitable for the operation (e.g. forklift trucks must only carry people if a suitable attachment has been installed, such as a man-rider cage and if the truck has been subjected to any necessary inspections in order to allow the lifting of people).
- The equipment should be stable and secure, e.g. mobile cranes with outriggers must be located on firm, level ground to avoid the outriggers sinking and the crane tipping.
- Lifting equipment should be visibly marked with the safe working load (SWL) – the maximum load that the device is permitted to lift.
- Lifting operations should be planned, carried out and supervised by competent persons. For example, though it is possible to hire a crane and a driver, the lift should also be planned and supervised throughout – it is common practice to carry out a "contract lift" whereby the planning and execution of the entire lifting process is contracted out to the hire company.
- Equipment that is used to lift people may be subject to additional regulatory inspections.

Forklift Trucks

There are many different types of forklift truck, but they share a range of common hazards and safety precautions. The hazards associated with forklift trucks are:

- **Overturn of the truck** – the narrow and short wheelbase of the truck makes it unstable, so it can fall over sideways, or tip forwards or backwards very easily. We covered some of the poor practices that might cause a forklift truck to fall over in Element 2.
- **Fall of the load** – the load may fall from the forks of the truck onto the driver, or onto others standing nearby during a lifting operation.
- **Striking of pedestrians** – like all vehicles, a forklift will cause serious injury if it hits a pedestrian.
- **Fall or entrapment of a person riding on the forks** – workers often use the forks of a forklift as a working platform. This practice may result in a fall from height, or the worker becoming trapped between the mast of the forklift and fixed structures.
- **Fall from loading dock** – another common accident, where the forklift truck either falls through or off the loading dock that it was driving over to access the back of a lorry.

The **engine type** of the forklift truck is also a source of concern:

- **Battery-powered trucks** are commonly used in indoor workplaces. They present several hazards:
  - Charging batteries emit hydrogen gas, which is explosive.
  - Batteries contain dilute sulphuric acid, which is corrosive.
  - Batteries are extremely heavy and present a manual-handling risk if they have to be changed for charging purposes.
  - The electricity can cause arcing, shock, burns or fire.
  - Battery contents are an environmental hazard, requiring appropriate disposal.
  - Battery-powered vehicles can be very quiet or almost silent, increasing the risk of collision with pedestrians.
  - Battery leads can short and result in burns and electric shock.
- **Diesel-powered trucks** are commonly used outdoors. Hazards include:
  - Dermatitis caused by contact of diesel with the skin.
  - Diesel spills are a significant slip hazard.
  - Large spills might pollute the environment.
  - Exhaust fumes are toxic.
  - Those hazards associated with the bulk storage of diesel.
- **Liquid petroleum gas (LPG)-powered trucks** have the following hazards:
  - LPG is an explosive gas.
  - Exhaust fumes are toxic.
  - LPG cylinders are heavy and present a manual-handling risk during changing.
  - Those hazards associated with the storage of replacement cylinders, or bulk storage of LPG.

TOPIC FOCUS

The precautions for safe use of forklift trucks include:

- Restricting use to trained operators only.
- Routine visual inspection of the truck before use.
- Routine maintenance of the truck in accordance with the manufacturer's recommendations.
- Never using the forklift to lift people unless a proper working platform is attached.
- Ensuring that the load on the forks is secure and stable.
- Ensuring that the safe working load limits of the truck are not exceeded.
- Observing site speed limits.
- Never travelling with the forks raised.
- Never travelling with obstructed vision.

Forklift trucks **powered by different types of fuel** also require different precautions:

- **Battery-powered trucks:**
  - Batteries must be charged in well-ventilated areas only, away from ignition sources.
  - Sulphuric acid should only be handled when wearing appropriate PPE (gloves, apron and eye/face protection).
  - Battery handling should be mechanised.
  - The electrical risk may require the use of insulated tools and gloves.

- **Diesel-powered trucks:**
  - Should only be used in a well-ventilated area.
  - Spill kits should be available.
  - Gloves should be worn when handling diesel.
- **LPG-powered trucks:**
  - Should only be used in a well-ventilated area.
  - LPG cylinder handling should be mechanised.
  - Spare cylinders must be stored in a secure, safe, well-ventilated location.

Hoists

We looked at smaller, manually-operated "people hoists" earlier – here, we will consider larger hoists, from passenger lifts to construction-site hoists.

A hoist

The main hazards associated with hoists are:

- Falling objects – such as the load falling from the hoist, or the hoist itself falling owing to structural failure.
- Being struck by the load during a lifting operation.
- Becoming entangled in moving parts.

When the equipment is used to carry people, as with a passenger lift, additional hazards exist:

- Falls from height – from a landing level, or from the platform of the lift itself.
- Being struck by landing levels, parts of any enclosure, or other projections while riding on the platform of the lift.

Precautions for safe use of hoists and lifts include:

- Ensuring that the hoist or lift is suitable for its intended use – in particular, people should only be carried on equipment specifically designed for that purpose.
- Preventing people from getting underneath the hoist, or lift platform, or the load during a lifting operation by enclosing the base of the lift or hoist with a fence.
- Preventing people from gaining access to an unprotected landing edge – with a passenger lift, having safety interlocks fitted on the doors at each landing.
- Preventing people being carried on the lift platform from being struck by landings or other obstructions as the lift moves – by constructing an enclosure around the lift platform.
- Observing the maximum safe working load of the lift or hoist, which should be clearly displayed.
- Ensuring that all safety devices, such as brakes, freefall brakes and interlocks are in full working order.
- Restricting the use of the hoist or lift, where necessary, to trained, competent people.
- Providing information, instruction and training as required.
- Routine maintenance by competent engineers.
- Routine inspection and thorough examination, as required.

Manually-Operated and Powered Load-Handling Equipment

Conveyors

Conveyors use belts, rollers or screws to move articles or material around and are frequently used in manufacturing and distribution.

A belt conveyor

The main hazards associated with conveyors are:

- In-running nip points - where fingers might be drawn into moving parts.
- Entanglement – where loose clothing might become entangled with rotating parts.
- Falling objects – from overhead conveyor systems.

The precautions for safe use of conveyors include:

- Warning alarms or sirens to alert people that the belt is about to start moving.
- Guarding of moving parts to prevent drawing in and entanglement, as far as is possible.
- Ensuring that emergency stop buttons or pull-cords are fitted and available for use.
- Barriers to exclude people from the area (protects also from falling objects).
- Fitting guards underneath overhead conveyors to catch falling objects.
- Information, instruction and training for operators.
- Controlling loose clothing and long hair, e.g. by the use of overalls and hairnets in the workplace.
- Maintenance by authorised persons only to ensure safe running.
- Provision of a defect reporting system.

Cranes

Many different types of crane are used in workplaces, from small derricks bolted to the floor at the edge of a loading bay, to large tower cranes positioned at the top of sky-scrapers during construction. We will use a mobile crane as a typical example.

Mobile crane

The main hazards associated with a mobile crane are:

- The crane collapsing or toppling over.
- The arm (jib) of the crane striking against other structures during movement.
- The load (or part of it) falling.
- The load striking against objects or people while being manoeuvred.
- Contact with live overhead cables.

TOPIC FOCUS

Factors that might make a mobile crane unstable and topple over:

- Overloading the crane beyond its lifting capacity.
- Siting the crane on uneven or unstable ground.
- Failure to use the outriggers (legs) correctly.
- Using the crane in high winds.
- Extending the jib of the crane too far out for the weight being lifted.
- Structural failure of parts (perhaps due to lack of maintenance).

Unstable load

REQUIREMENTS FOR SAFE LIFTING OPERATIONS

- Ensuring the crane or lifting device is of the correct type for the job and terrain; that it is strong and stable.
- Ensuring that the load to be lifted is within the safe lifting capacity of the crane (which should be clearly marked on the crane) – safe lifting capacity will vary with the length of the jib and the distance away from the crane that the jib is positioned (radius), so capacity can vary from one lift to the next.
- Carefully siting the crane on even, stable ground in a safe position away from structures or overheads that might be struck during the lifting operation.
- Using the outriggers correctly.
- Checking that the crane has been maintained and has a certificate of thorough examination in accordance with local laws.
- Restricting use of the crane to trained and competent operators.
- Ensuring that each lift is planned and supervised by a competent person and that the driver and slinger are competent.
- Providing a banksman to give directions to the crane operator, with good means of communication between driver and other operators.
- Ensuring that safety devices such as overload indicators are operational and are used correctly – these devices are frequently disabled, or ignored by the crane operator.
- Checking that there are no obstructions, such as buildings or overhead lines, in the vicinity of the lift.
- Checking weather conditions and obeying any manufacturer's recommendations about maximum wind speed.
- Lifting the load as close to the ground as possible; never lifting the load directly over a person.
- Using PPE, such as hard hats, steel toe-cap boots and hi-vis clothing.
- Using signs to warn of the operations and exclusion of personnel from the area.

GLOSSARY

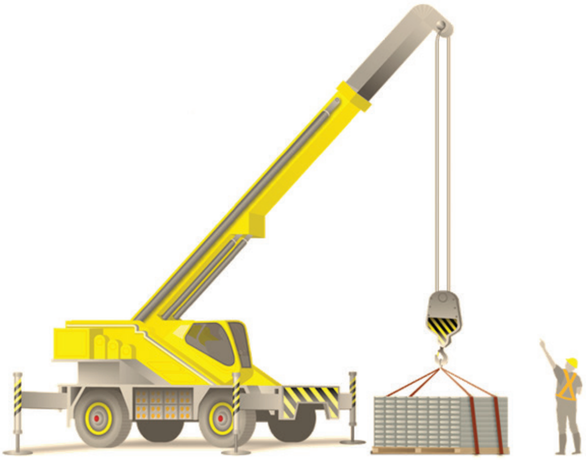
SLINGER

The competent person responsible for preparing and slinging a load in readiness for a crane lift, and for attaching or detaching load slings from the crane hook.

Manually-Operated and Powered Load-Handling Equipment

It is also important to consider the lifting accessories that are used to attach the load to the crane: items such as chains, wire ropes, nylon slings, or eye-bolts and shackles. These must be:

- In good condition.
- Fitted to the load by competent people.
- Regularly checked by pre-use visual inspection and subjected to thorough examination as dictated by local law.



Crane lift being supervised

REQUIREMENTS FOR PERIODIC EXAMINATION OF LIFTING EQUIPMENT

Lifting equipment is placed under a great deal of strain. If it is not maintained in good working order it can fail catastrophically. This will almost certainly happen under load, when the maximum damage will be done. Fatalities frequently occur as a result of catastrophic lifting-equipment failures. There are, therefore, legal requirements about the thorough examination and testing of lifting equipment to ensure strength and stability. The legal requirements vary, depending on region and type of equipment.

In general, lifting equipment should be thoroughly examined:

- Before it is used for the first time (unless it has an in-date certificate of thorough examination from the manufacturer, or previous owner).
- Before it is used for the first time, where the way that it has been installed will make a difference to its strength and stability.
- Periodically.
- After an event that may have affected its strength and stability.

The frequency of "periodic" thorough examination will typically be:

- Every 12 months for equipment that is not used to carry people.
- Every six months for equipment that is used to carry people.
- Every six months for lifting accessories.

This examination and testing must be carried out by a competent engineer.

MORE...

The UK Health and Safety Executive (HSE) provides guidance on the use of lifting and handling aids:

http://www.hse.gov.uk/pubns/indg398.pdf

REVISION QUESTIONS

11. What are the most common hazards associated with the following lifting/moving equipment?
    (a) Forklift trucks.
    (b) Sack trucks.
    (c) Lifts and hoists.
    (d) Cranes.
12. What personal protective equipment might be appropriate for working with the following lifting/moving equipment?
    (a) Pallet trucks.
    (b) Cranes.
13. What are the typical safety precautions for safe use of a mobile crane?

(Suggested Answers are at the end.)

SUMMARY

This element has dealt with manual and mechanical-handling hazards and the associated control measures.

In particular it has:

- Described the key types of musculoskeletal disorders, including back injuries, work-related upper limb disorders (WRULDs) and chronic soft-tissue injuries, and listed some examples of the types of high-risk, repetitive operations that cause them.
- Defined ergonomics, identified the musculoskeletal disorders associated with poor design, and identified factors that influence ergonomic risk, such as repetition, force, posture, twisting, rest breaks, equipment design and adjustability, and workplace lighting.
- Explained how the workplace should be matched to individual needs, using ergonomic principles.
- Outlined the ill-health effects of poor task and workstation design, as well as the risk factors that influence the risk of musculoskeletal disorders.
- Described appropriate control measures to reduce the risk of musculoskeletal disorders, including the application of ergonomic principles to DSE use and factory assembly-line work.
- Outlined the main types of injury associated with manual handling as musculoskeletal disorders, such as injury to the back, tendons, ligaments, muscles and work-related upper limb disorder (WRULD).
- Described the four main factors that have to be considered during a manual-handling risk assessment: the task, the load, the environment, and individual capabilities.
- Explained how risk associated with manual handling can be controlled by automating or mechanising the handling; using handling aids; modifying the task, load or environment; and by ensuring individual capabilities are matched to the activity.
- Noted the basic principles of safe lifting technique before the lift, during the lift, and when setting down.
- Considered the hazards and safety precautions associated with different types of lifting and moving equipment, such as pedestrian (manually) operated trucks, including people-handling aids, and powered equipment, such as forklift trucks, lifts, hoists, conveyors and cranes.
- Outlined the typical hazards as:
  - Collapse or toppling of the equipment.
  - Falls from height.
  - Falling objects.
  - Being struck by the equipment or the load during movement.
- Outlined the general precautions as:
  - Suitability in terms of strength and stability.
  - Correctly positioned and installed.
  - Marked with the safe working load.
  - Used by competent operators under competent supervision.
  - Maintained in a safe working condition.
  - Only used for carrying people if the equipment has been designed for that purpose and all additional safety requirements have been implemented.
- Explained how lifting equipment should be routinely inspected and subjected to thorough examination by a competent engineer.

QUESTION

(a) **Give FOUR** specific types of injury that could be caused by the incorrect manual handling of loads. (4)

(b) **Identify** factors in relation to the load that will affect the risk of injury. (4)

APPROACHING THE QUESTION

Think now about the steps you would take to answer the question:

1. The first step is to read the question carefully. Note that part (a) just asks for four injuries caused by manual handling, so you don't need any more detail than that, and only the first four items in your list will be marked. Part (b) asks you to identify factors, which means that you can "give without explanation". Your answers will therefore be quite short.

2. Next, consider the marks available. In this question there are eight marks split equally between parts (a) and (b). In part (a) you are asked specifically for only four facts, but in part (b) we can deduce that the examiner is looking for four factors, as there are four marks available. However, in this case, if you can think of a couple of additional factors, it would increase your likelihood of gaining full marks. The question should take around eight minutes in total in an exam.

3. Now highlight the key words. In this case they might look like this:

   (a) **Give FOUR** specific types of injury that could be caused by the incorrect manual handling of loads.
   (4)

   (b) **Identify** factors in relation to the load that will affect the risk of injury.
   (4)

3. Read the question again to make sure you understand it and have a clear understanding of manual-handling injuries and factors specifically relating to the load lifted. (Re-read your notes if you need to.)

4. The next stage is to develop a plan – there are various ways to do this. Your answer must be based on the key words you have highlighted. Remind yourself, first of all, that you need to be thinking about "What types of injury are caused by manual handling?" and then "What is it about the load that can cause injuries?"

Now have a go at the question. Draw up an answer plan, and then use it as the basis to write out an answer as you would in the exam.

When you have finished, compare your plan and full answer with those that follow.

SUGGESTED ANSWER

Plan

Manual-handling Injuries	Individual
• Strains. • Sprains. • Cuts and lacerations. • Crushes, e.g. fingers and toes. • Prolapsed discs. • Hernias.	• Weight. • Size. • Centre of gravity. • Whether static or shifting load. • Sharp edges. • Hot surfaces. • Absence of hand-holds and grip difficulties.

POSSIBLE ANSWER BY EXAM CANDIDATE

(a) *Common manual-handling injuries include:*

- *Strained muscles.*
- *Strained ligaments and tendons.*
- *Cuts to the hands.*
- *Hernias.*

(b) *There are many factors relating to the load that affect the risk of manual-handling injury. Firstly, the weight of the load being lifted is important, together with the size of the object (a bulky item may be harder to lift than a small item). If the load's centre of gravity is off-centre, this can cause the load to tip. The load may have intrinsic hazards, such as hot or sharp surfaces that can cause injury when touched. A load which moves during lifting, e.g. a container of liquid, may have a moving centre of gravity, causing it to tip.*

REASONS FOR POOR MARKS ACHIEVED BY CANDIDATES IN EXAM

- Many candidates failed to list specific types of injury – general terms such as "back pain" or "musculoskeletal injuries" were not sufficient to be awarded marks.
- Most candidates found part (b) of this question straightforward, although some didn't read the question and gave factors relating to the individual, task or environment, which wouldn't be awarded marks.

WORK EQUIPMENT HAZARDS AND RISK CONTROL

ELEMENT 4

LEARNING OUTCOMES

On completion of this element, you should be able to demonstrate understanding of the content by applying what you have learnt to familiar and unfamiliar situations. In particular, you should be able to:

1. Outline general requirements for work equipment.
2. Explain the hazards and controls for hand-held tools.
3. Describe the main mechanical and non-mechanical hazards of machinery.
4. Explain the main control methods for reducing risk from machinery hazards.

Contents

General Principles for Selection, Use and Maintenance of Work Equipment

KEY INFORMATION

- Work equipment covers a wide range of hand-held tools, powered tools and machinery.
- Work equipment should be suitable for the task it is being used for and the environment it is used in.
- Access to dangerous parts of machinery should be prevented and safeguards applied according to a hierarchy of control measures.
- It is often necessary to restrict the use of work equipment to competent operators only.
- Information, instruction and training should be provided for equipment users, managers and maintenance staff.
- Work equipment should be maintained in safe working order and maintenance activities carried out safely. Routine inspection of equipment is sometimes necessary to ensure its safe condition. Pressure systems require periodic examination and testing.
- Equipment controls should be clearly labelled and accessible; this is particularly important for stop controls and emergency stops.
- Work equipment should be stable, adequately marked with appropriate warning signs, and devices and environmental factors, such as lighting and space, should be managed.
- Operators must obey rules for the safe use of work equipment.

There are some general safety principles that can be applied to all items of work equipment, irrespective of type.

TYPES OF WORK EQUIPMENT

In this element we will use the phrase "work equipment" in a very wide sense to include:

- Simple hand tools, e.g. a hammer, screwdriver or chisel.
- Hand-held power tools, e.g. a portable electric drill or circular saw.
- Single machines, e.g. a bench-mounted abrasive wheel, photocopier, lathe or compactor.
- Mobile work equipment, e.g. a tractor or mobile crane.
- Machine assemblies, where several machines are linked together to form a more complex plant, such as a bottling plant.

SUITABILITY

In terms of the provision of equipment, all items of work equipment should be suitable for the:

- **Task** it is going to be used to perform, e.g. a chisel is not appropriate for prising lids off tins.
- **Environment** in which it is to be used, e.g. a standard halogen spotlight is not suitable for use in a flammable atmosphere.

Equipment must be carefully selected to ensure that it is suitable for the task and environment on the basis of manufacturers' information.

In many regions of the world there are regulations that require manufacturers to ensure that the equipment that they produce meets basic safety standards. For example, in the European Union, a set of safety standards exists that manufacturers are legally obliged to meet. Manufacturers are required to:

- Fix a "CE" (Conformité Européenne) mark to the equipment;
- Provide a written "Declaration of Conformity" for the purchaser.

CE Mark

Employers in the European Union have to ensure that any equipment they purchase for work use has this CE mark and written declaration.

General Principles for Selection, Use and Maintenance of Work Equipment

PREVENTION OF ACCESS TO DANGEROUS PARTS OF MACHINERY

Generally, if a piece of work equipment could cause injury when being used in a foreseeable way, it can be considered a dangerous part. Access to dangerous parts of machinery should be prevented and safeguards applied according to a hierarchy of control measures.

The levels of protection (hierarchy of controls) are:

- Fixed enclosed guards.
- Other guards and protection devices, such as interlocked guards and pressure mats.
- Protection appliances, such as jigs, holders and push-sticks.
- The provision of information, instruction, training and supervision.

These will be covered in more detail later.

These safeguards use one of three distinct principles. They:

- Place a physical barrier between a person and the dangerous part.
- Use devices that only allow access while the equipment is in a safe condition.
- Detect a person's presence and stop the machine.

RESTRICTING USE

Use of work equipment should, where necessary, be restricted to competent operators only. This relates to all equipment where risk of serious injury to the operator or to others ("specific risks") exists, e.g. a metal-working lathe.

Repair, modification or maintenance of equipment should be restricted to designated competent people.

INFORMATION, INSTRUCTION AND TRAINING

Work-equipment users should be provided with appropriate information, instruction and training:

- Where the equipment is **low risk**, this requirement is simple to fulfill. For example, an office paper shredder can be used by staff who have read the instructions supplied by the manufacturer.
- With **high-risk** machinery (machinery with "specific risks") more has to be done to fulfill this requirement to an acceptable standard. For example, an employer operating an industrial shredder capable of shredding wooden pallets should ensure that all operators receive specific training in the safe use of the equipment, as well as written information. They should also check to ensure that training and information are understood.

Those involved in the **management of operators** should be given adequate information, instruction and training to allow them to manage effectively. As a minimum they should understand the basic principles of safe use of the equipment.

Maintenance staff should be given specific information, instruction and training so that they:

- Can undertake any maintenance activities with a minimum of risk to themselves and others.
- Understand the maintenance requirements of the equipment and are able to keep the equipment in safe working order.

MAINTENANCE REQUIREMENTS

Work equipment should be maintained in a safe working condition, according to any legal standards that exist and manufacturers' recommendations.

Engineer carrying out condition-based maintenance

Maintenance can be carried out according to various regimes, such as:

- **Planned preventive maintenance (PPM)** – where servicing work is carried out at prescribed intervals and parts are replaced or changed, irrespective of their condition. For example, oil in an engine might be changed every year regardless of the amount of use that the engine has received.
- **Condition-based maintenance** – where servicing is carried out and parts changed only where inspection indicates that use has caused deterioration. For example, the brake pads on a car might be inspected every 10000km but only changed when they show signs of heavy wear.

- **Breakdown maintenance** – where maintenance is only carried out during repair.

Whatever type of maintenance regime is used for an item of work equipment, staff must not be exposed to unacceptable risk during maintenance work.

Maintenance work often creates greater risk for the staff involved because:

- Guards and enclosures have to be removed to allow access.
- Safety devices have to be removed or disabled.
- Equipment has to be partially or completely dismantled.
- Power sources may be exposed (e.g. electrical supply).
- Stored power may be accidentally released (e.g. compressed spring).
- Access may be awkward (e.g. space constraints or work at height).
- Handling of parts may be difficult (e.g. heavy parts).
- Additional hazards may be introduced (e.g. power tools).

TOPIC FOCUS

Additional precautions may be required during maintenance work:

- Maintenance should only be carried out by competent staff.
- Power sources should be isolated and physically locked off (secured).
- Stored power should be released or secured to prevent accidental discharge.
- Where power cannot be isolated, additional precautions are required:
  - Cover live parts with insulating material.
  - Use additional PPE, such as insulating rubber gloves.
- If dangerous moving parts have to be accessed, additional precautions are required:
  - Run at very slow speed (rather than normal operating speed).
  - Fit maintenance guards that have been made specifically to allow minimum access to required areas only.
- Precautions should be taken to allow safe access, especially when working at height.
- Handling aids and equipment should be used to reduce manual-handling risk.

A safe system of work should be developed for when maintenance work is carried out; this may require the use of a permit-to-work and adequate levels of supervision (as covered in Unit IGC1).

For some items of work equipment it is foreseeable that safety-critical parts might deteriorate and it is possible for these parts to be inspected without dismantling the equipment. It may be necessary to introduce some form of inspection regime. For example, the tyres on a vehicle might go flat, or become excessively worn and it is an easy matter for the driver of the vehicle to carry out a pre-use inspection to check their condition.

In certain instances this routine inspection should be combined with a more detailed periodic examination and testing. For example, pressure systems, such as boilers and air receivers, must be thoroughly examined and tested because they are subject to very heavy stresses, and if parts were to fail they would fail catastrophically, leading to explosion. Periodic examination and testing of pressure systems should be carried out by a competent engineer.

EQUIPMENT CONTROLS AND ENVIRONMENTAL FACTORS

Equipment controls, such as stop and start buttons, should be:

- Well designed so they are easy to use.
- Placed at suitable locations on the equipment.
- Easily identifiable.
- Kept in good working order.
- Compliant with relevant standards.

It is particularly important that stop controls are easy to see and reach, and that they override all other controls.

Many machines should also have emergency stops fitted. These are controls that bring the equipment to a safe stop as quickly as possible. Emergency stops can be buttons or pull cords and should be positioned on or by the equipment, within easy reach of operators. For large machines this means that several emergency stop buttons may be fitted at various locations around the machine.

Emergency stop button

General Principles for Selection, Use and Maintenance of Work Equipment

In addition to the requirements outlined earlier, there are some other basic physical requirements that work equipment should meet. It should:

- Be **stable** – this may mean bolting it to the floor, or fitting outriggers, jacks or stabilisers.
- Be **appropriately marked** – with labels on control panels, safe working loads, maximum speeds, direction of movement, etc.

  All work equipment has to be marked in a clearly visible manner, giving any relevant health and safety information, such as:
  - Stop and start controls.
  - Abrasive-wheel rotation speeds.
  - Safe working loads.
  - Colour-coding of gas cylinders for recognition of contents.
  - Contents of storage vessels and the nature of any hazardous contents.
  - Colour-coding of pipework.
- Have appropriate warnings – such as warning signs by dangerous parts and, in some cases, visible and audible warnings, such as flashing beacons and klaxons to warn of the start up or movement of machinery.

  All work equipment should incorporate any warnings or warning devices that are appropriate for health and safety. These can be in the form of notices, requirements within permits-to-work and safety signs.

  Warning devices can be items that emit a warning sound or light signal, such as a siren or flashing beacon, or combination of both.

The physical environment around work equipment must also be considered, in particular lighting and space:

- **Lighting** considerations:
  - Adequate general workplace lighting should be provided around equipment for the safety of both operators and others in the vicinity.
  - Local lighting, such as spotlights positioned above machinery, might be required to give higher levels of light on critical areas.
  - Lighting should be suitable for the type of equipment in use; avoid lights that flicker when illuminating rotating machinery because of the "stroboscope effect", where the rate of flicker coincides with the rotation rate of the machinery, giving the impression that the machinery is rotating very slowly when, in reality, it is rotating quickly.
  - Lighting should be suitable for the environment (e.g. intrinsically safe lighting used in a flammable atmosphere).
- **Space** considerations:
  - Operators should have adequate space to move around work equipment safely.
  - Other people should be able to move around safely without coming into close proximity to dangerous parts, or presenting a hazard to the operator.

RESPONSIBILITIES OF USERS

You may remember from Unit IGC1 that employees have a duty to take reasonable care of their own health and safety and that of others who might be affected by their acts or omissions. This is particularly relevant with regard to the use of work equipment.

Users of work equipment should:

- Only use equipment they are authorised to use.
- Use equipment in accordance with instruction and training.
- Only use equipment for its intended purpose.
- Carry out all necessary safety checks before using equipment.
- Not use the equipment if it is unsafe.
- Report defects immediately.
- Not use equipment under the influence of drugs or alcohol (this includes some medication that causes drowsiness).
- Keep equipment clean and maintained in safe working order.

REVISION QUESTIONS

1. Why are maintenance workers sometimes at greater risk than operators when working on machinery?
2. What are the general health and safety responsibilities of machine operators?

(Suggested Answers are at the end.)

Hand-Held Tools and Portable Power Tools

KEY INFORMATION

- Simple hand tools can cause injury through user error, misuse or mechanical failure.
- Safe use of hand tools requires user training, compliance with safety rules, and routine inspection and maintenance of the tools.
- Portable power tools present greater risks because of the severity of injury that might be caused and the additional hazards presented by each tool.
- Safe use of power tools requires the same basic approach as that for hand tools, but with greater emphasis on user competence, supervision and maintenance, with additional precautions being introduced to combat each of the hazards associated with a tool and its power source.

HAZARDS OF HAND-HELD TOOLS AND REQUIREMENTS FOR SAFE USE

Simple hand tools, such as a hammer, chisel or screwdriver, present relatively simple hazards:

- The tool may shatter during use, throwing off sharp metal fragments (e.g. a hammer head or chisel blade).
- The handle may come loose during use (e.g. an axe head comes off its handle).
- The tool may be blunt, leading to use of excessive force which causes loss of control (e.g. blunt knife).
- Simple human error, where the user misjudges a movement (e.g. hits their own thumb with hammer).
- The tool may be misused, i.e. used in an inappropriate way, or for an inappropriate task (e.g. a screwdriver used as a crowbar).

Some relatively simple precautions can therefore be applied to ensure safe use of hand tools:

- Tools must be **suitable** for the **task** that they are going to perform and for the **environment** in which they are to be used, e.g. non-sparking tools (which do not produce sparks when struck) are suitable for use in a potentially flammable atmosphere.
- Users should be given appropriate **information**, **instruction** and **training**. Many workers serve some form of apprenticeship, or spend several years in training where they acquire an understanding of safety in the use of the tools for their trade, but not all workers come to the workplace with this knowledge.
- Tools should be **visually inspected** routinely before use to ensure they are in an acceptable condition. This should be done by the user. Spot checks by line management will ensure that users comply. Sub-standard tools should be maintained or discarded.
- Tools should be **maintained** in a safe condition and be fit for use, e.g. blades should be kept sharp and handles firmly attached; chisels should have 'mushroom' heads ground off to prevent metal splinters breaking off when struck.
- **Supervision** is important to ensure that safe working practices are adhered to and misuse does not become commonplace.

Even simple tools, such as hammers, can be hazardous

HAZARDS AND CONTROLS FOR PORTABLE POWER TOOLS

Portable power tools create greater risk than simple hand tools because:

- The forces generated by the tool are far greater, so the potential for very severe injury or death exists (a ruptured disc from a disc cutter will cut an arm off, which is not going to happen with a hand saw).
- Power tools have additional hazards not present with simple hand tools.

Additional hazards from portable power tools are:

- Electricity – which may result in electric shock, burns, arcing or fire.
- Fuel – usually petrol, which creates a fire and explosion risk.
- Noise – which may cause hearing loss.
- Vibration – which may cause hand-arm vibration syndrome.

- Dust – which is harmful if inhaled.
- Ejection – of material (e.g. brick fragments) or tool parts (e.g. cutting-disc fragments).
- Trip hazards from power cables.

Construction worker using portable power tool

Because the risks created by portable power tools are greater than those associated with hand tools, the safety precautions are more stringent. Management should ensure that:

- Tools are carefully selected to ensure **suitability** for the **task** and **environment**.
- **Instructions** and safety rules are available in the form of manufacturers' handbooks, or in-house safe working procedures.
- Operators are **trained** and given **information** on safe use of the tool. Operator competence is a key control that should be verified.
- Operators are **supervised** to ensure safe use.
- Tools are routinely **inspected** by the operator before use. Additional formal inspections should be carried out by the supervisor or maintenance staff. Sub-standard tools must be repaired or discarded.
- Tools are **maintained** in safe working order. This might be done according to a maintenance schedule.
- Maintenance must be carried out by competent personnel only and records should be kept. The tool might be labelled to indicate the date of next maintenance.

In practice, safe use of a portable power tool requires that:

- Tools and parts are only used for their intended purpose, within their design specification (e.g. the maximum speed of a cutting disc should not be exceeded) and in an environment that they are suitable for.
- Necessary guards and safety devices are always used (e.g. the self-adjusting guard fitted to a portable circular saw).
- Necessary personal protective equipment is always used (e.g. eye protection when using a chain saw).
- Trailing power cables or pipes are carefully positioned so that they do not present a trip hazard and will not be damaged by the tool or passing vehicles, etc.
- Care is taken to ensure that ejected parts do not present a risk to others nearby. This may require that the area is fenced or cordoned off, or that the tool is only used at specific times.
- Dust exposure is controlled, either by damping down or by the use of respiratory protective equipment by the operator and others nearby.
- Noise exposure is controlled, e.g. by using hearing protection (see Element 8).
- Vibration exposure is controlled, e.g. by job rotation or limiting the duration of tool use (see Element 8).

Additional precautions are necessary when storing and handling **petrol**. It should be:

- Stored in an appropriate, labelled metal container in a well-ventilated, secure area away from ignition sources.
- Handled with care in a well-ventilated area (preferably outside) away from ignition sources. Any spillages should be dealt with immediately (see Element 6).

Additional precautions must be taken when using electrical equipment. Battery-operated tools might be used, or a low voltage supply (e.g. 110V rather than 240V). Damage to the electrical cord must be avoided.

The tool, cord and plug should be routinely inspected by the operator prior to use. It should also be given a formal electrical safety inspection and thorough examination and test (see Element 5).

REVISION QUESTIONS

3. (a) From what do the risks in the use of hand tools arise?

   (b) From what do the additional risks of portable power tools arise?

4. Why might each power tool be marked?

(Suggested Answers are at the end.)

Machinery Hazards

KEY INFORMATION

- The mechanical hazards of machinery are: crushing, shearing, cutting or severing, entanglement, drawing in or trapping, impact, stabbing or puncture, friction or abrasion, and high-pressure fluid injection.
- The non-mechanical hazards of machinery are: electricity, noise, vibration, hazardous substances, radiation (ionising and non-ionising), extreme temperatures, ergonomics, slips, trips and falls, and fire and explosion.
- All machinery, from simple office machinery (such as a photocopier or document shredder) to construction machinery (such as a cement mixer or bench-mounted circular saw), present a range of both mechanical and non-mechanical hazards.

MECHANICAL AND NON-MECHANICAL HAZARDS

The hazards of machinery can be divided into:

- Mechanical hazards – mainly from contact with or being caught by dangerous moving parts.
- Non-mechanical hazards – mainly from the power source or things emitted by the machine.

This follows **ISO 12100:2003** (Parts 1 and 2) *Safety of Machinery*.

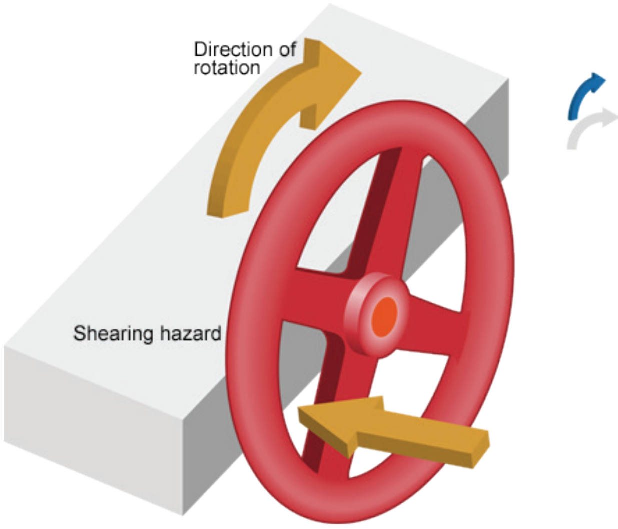
Mechanical Hazards

The mechanical hazards of machinery can be further sub-divided into the following classes:

Crushing – the body is trapped between two moving parts or one moving part and a fixed object (e.g. a hydraulic lift collapses, crushing a person underneath it).

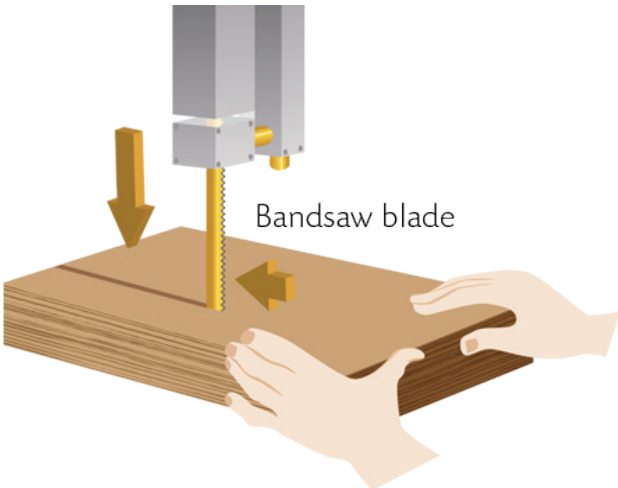
Crushing – the person is crushed between the moving object and the wall

Shearing – a part of the body (usually the fingers) is trapped between two parts of the machine, one moving past the other with some speed. The effect is like a guillotine, cutting off the trapped body part.



Shearing – a finger put through the spokes of this wheel will be cut off

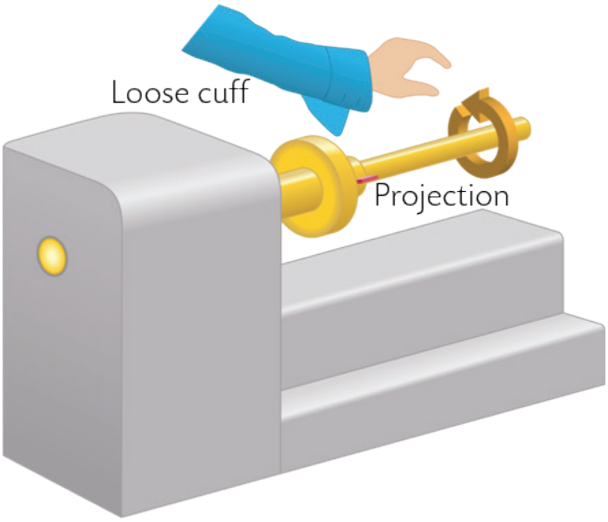
Cutting or severing – contact is made with a moving sharp-edged part, such as a blade (e.g. the blade of a bandsaw).



Cutting or severing – if the hands come into contact with the moving blade severe laceration or amputation will occur

Machinery Hazards

Entanglement – loose items such as clothing or hair get caught on a rotating machine part and the person is drawn onto the machine.

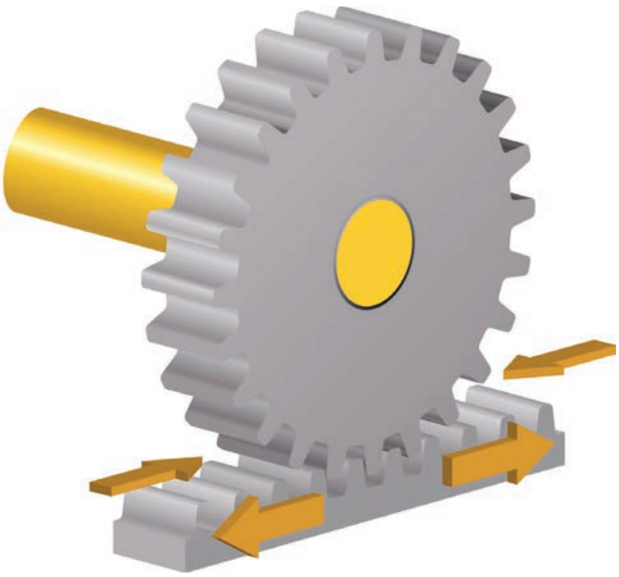


Entanglement – a loose sleeve cuff becomes entangled with the chuck of a lathe

Impact – the body is struck by a powered part of a machine (this is similar to crushing, but there is no fixed structure to trap the person; the speed and weight of the object does the damage).

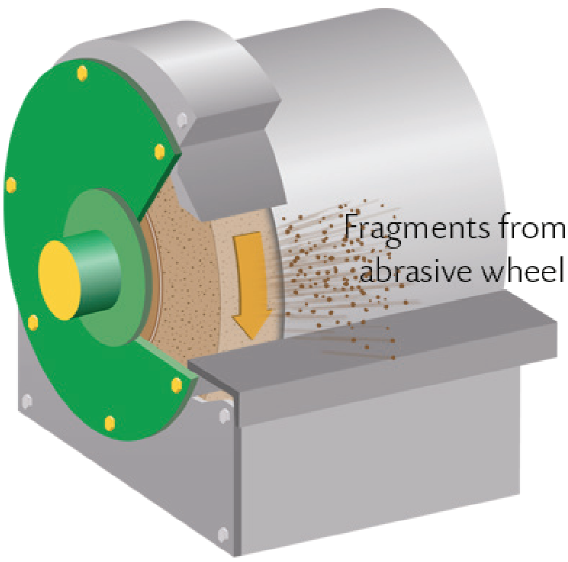
Impact – the person is struck hard by the heavy and fast-moving industrial robot

Drawing in or trapping - a part of the body is caught between two moving parts and drawn into the machine, e.g. at "in-running nips", where two counter-rotating rollers meet.



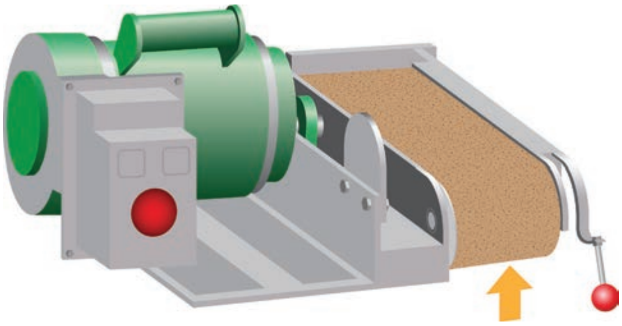
Drawing in or trapping - if the rollers are touched at the in-running nip point then the hand will be drawn in by the two rollers

Stabbing or puncture – sharp parts of the machine, or parts or material ejected from the machine, penetrate the body (e.g. swarf, sewing-machine needle, abrasive wheel fragments, nails from a nail gun).



Stabbing or puncture – small fragments of the abrasive wheel are ejected at high speed and can cause penetration injury, particularly to the eyes

Friction or abrasion - contact is made with a fast-moving surface, which may be smooth (e.g. touching a spin dryer) or rough (e.g. touching a belt sander).



Friction or abrasion – if the belt is touched while in motion, then abrasion occurs

High-pressure fluid injection – fluid at very high pressure is ejected from the machine and penetrates the skin (e.g. hydraulic fluid escaping from a burst hydraulic hose).

Other (Non-Mechanical) Hazards

The other hazards of machinery are non-mechanical hazards – those hazards that do not arise directly from contact with dangerous moving parts. They are mainly associated with the power source of the machine, or are things that it emits. In other words, they are all the hazards that remain once the mechanical hazards have been listed.

TOPIC FOCUS

Non-mechanical hazards of machinery:

- Electricity.
- Noise.
- Vibration.
- Hazardous substances.
- Ionising radiation.
- Non-ionising radiation.
- Extreme temperatures.
- Ergonomics.
- Slips, trips and falls.
- Fire and explosion.

We will cover these non-mechanical hazards in more detail in other elements of Unit GC2, so here we will just clarify two issues:

- Hazardous substances are often contained or used by machinery as an integral part of the process, e.g. a metal-cutting lathe uses cutting fluid to cool and lubricate the cutting bit. In other instances, hazardous substances are produced as a by-product of machine operation, e.g. a robot welder produces welding fumes.
- Ergonomic hazards result from the interaction of the machine operator and the machine – from the posture that the operator has to adopt during machine use and the stresses put on the body. For example, a construction worker using a concrete breaker may have to support the weight (roughly 8kg) of the breaker in order to cut a hole for a door lintel.

MACHINERY AND EQUIPMENT HAZARDS - SPECIFIC EXAMPLES

The following examples illustrate the hazards associated with typical machinery and equipment found in different types of workplaces. We will look at guards and other protection methods than can be used to control these hazards later in this element.

Office Machinery

Photocopier

- Drawing in and entanglement from contact with moving parts.
- Electricity.
- Contact with hot parts.
- Health hazard from ozone (irritant gas).

A typical photocopier

Paper Shredder

- Cutting and drawing in (in-running nip between cutter blades).
- Electricity.
- Ergonomic hazard from handling of waste.

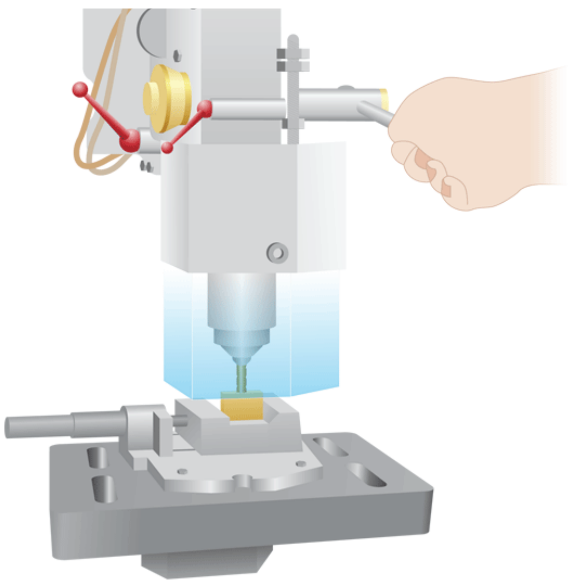
Manufacturing and Maintenance Machinery

Bench-Top Grinder

- Abrasion on contact with rotating abrasive wheel.
- Drawing in at nip-point between wheel and tool rest.
- Ejection of parts of the wheel during normal use, or if it bursts.
- Entanglement with the spindle on which the wheel is mounted.
- Electricity.
- Hot parts caused by friction (especially the workpiece being ground).
- Health hazard from dust.
- Noise and vibration.

Pedestal Drill

- Entanglement with the rotating drill bit or chuck.
- Stabbing or puncture by the drill bit during normal use, or if the bit breaks.
- Puncture by swarf ejected during metal-cutting.
- Impact if struck by the workpiece if the bit jams and the workpiece rotates.
- Drawing in at nip-points between motor and drive belts.
- Electricity.
- Noise.
- Hot parts (especially the drill bit).
- Health hazard from cutting fluid (e.g. dermatitis).



Pedestal drill

Agricultural and Horticultural Machinery

Cylinder Mower (Petrol-Driven, Ride-On Type)

- Cutting on contact with moving blades.
- Impact or crushing if struck by the mower.
- Entanglement with various rotating parts.
- Drawing in at various nip-points.
- Noise.
- Vibration.
- Fire and explosion from petrol (fuel).
- Health hazard from sensitisation to grass sap, pollen, etc.

Strimmer or Brush-Cutter (Petrol Driven)

- Cutting on contact with moving cutting head.
- Entanglement with rotating cutting head.
- Puncture by objects ejected by cutting head (e.g. stones).
- Noise.
- Vibration (into hands).
- Fire and explosion from petrol (fuel).
- Ergonomic from repetitive movement, twisting, carrying.
- Health hazards from sensitisation to grass sap, pollen, etc.
- Health hazard from ejected animal faeces.

Chainsaw (Petrol Driven)

- Cutting on contact with moving blade.
- Entanglement with moving blade.
- Drawing in at nip-point between blade and casing.
- Puncture by ejected parts (especially broken blade fragments).
- Burns from the hot exhaust system.
- Noise.
- Vibration (into the hands).
- Fire and explosion from petrol (fuel).
- Ergonomic from handling.
- Health hazards from dust, fumes and lubricating oils.

Retail Machinery

Compactor

- Crushing, if a person is inside during operation.
- Shearing between moving arms during operation.
- Crushing or impact by ejected bale or container lorry.
- Electricity.
- High-pressure fluid ejection from hydraulic system.
- Ergonomics from handling material during loading.

Checkout Conveyor System

- Drawing in at nip-points on belt system (e.g. where belt meets counter top).
- Entanglement with motor or rollers driving the belt.
- Friction on contact with moving belt.
- Electricity (motor).
- Ergonomics from handling items while seated.
- Non-ionising radiation from laser bar-code scanner.

Construction Machinery

Cement Mixer

- Entanglement with rotating drum or drive motor.
- Drawing in at nip-point between motor and drive mechanism.
- Crushing between drum and drum stop when tipping.
- Friction or abrasion on contact with moving drum.
- Electricity.
- Ergonomics and manual-handling injuries during loading.
- Health hazard from cement-dust inhalation (irritant) and contact with wet cement (corrosive).
- Hazards due to the fuel (electricity or petrol).
- Being struck by vehicles operating in the area.

Bench-Mounted Circular Saw

- Cutting on contact with blade.
- Entanglement with drive motor.
- Drawing in at nip-points between motor and drive belt.
- Ejection of workpiece during cutting.
- Electricity.
- Noise.
- Health hazard from inhalation of wood dust.

MORE...

Further information about the safe use of work equipment and machinery is available from the UK Health and Safety Executive (HSE):

http://www.hse.gov.uk/equipment/index.htm

REVISION QUESTIONS

5. What hazards might arise from the use of the following machines?

   (a) Bench-top grinder.

   (b) Chainsaw.

   (c) Bench-mounted saw.

6. What are drawing-in injuries?

7. List the non-mechanical hazards arising from the use of machinery.

(Suggested Answers are at the end.)

Control Measures for Reducing Risks from Machinery Hazards

KEY INFORMATION

- Guards and other protection methods must be used to control the risks associated with machinery. Even when most hazards can be eliminated through good design, other hazards will still remain.
- Protection from machinery hazards can be achieved by using guards that physically enclose the hazard and prevent contact. Fixed guards are most effective at preventing contact, but interlocked guards, adjustable guards and self-adjusting guards may be required.
- If it is not possible to completely guard in a hazard, then other forms of protection will have to be used, such as trip devices, two-hand controls, protective appliances, emergency stops, PPE, or information, instruction, training and supervision.
- Guards and safety devices must meet relevant standards: be strong and robust; compatible with machine operation; not easy to defeat; allow visibility and ventilation; take maintenance into account; and not increase overall risk.

It may be possible to eliminate the risk created by a piece of machinery by getting rid of the machine that creates the risk. However, this is not an option in most circumstances.

It is also possible that the hazards associated with a piece of machinery can be eliminated by good design. This is the job of the manufacturer and, in many regions, statute law exists to ensure that this approach is taken. But even when this is done, hazards will still remain.

It is, therefore, essential that further safeguards are used to control the remaining hazards. The best approach is to create a safe machine using engineering controls (such as fixed guards). In some situations it is not possible to guard-in a machine hazard, so other devices and appliances have to be applied.

Some hazards cannot be controlled by engineering means at all; in these cases, safety depends solely on operator behaviour. This is the least preferred option because operators are prone to human error and commit violations.

Here, we look at each of the safeguards that might be used, in order of preference. Usually a combination of the various safeguards is used to reduce risk to an acceptable level.

MACHINERY SAFEGUARDING METHODS

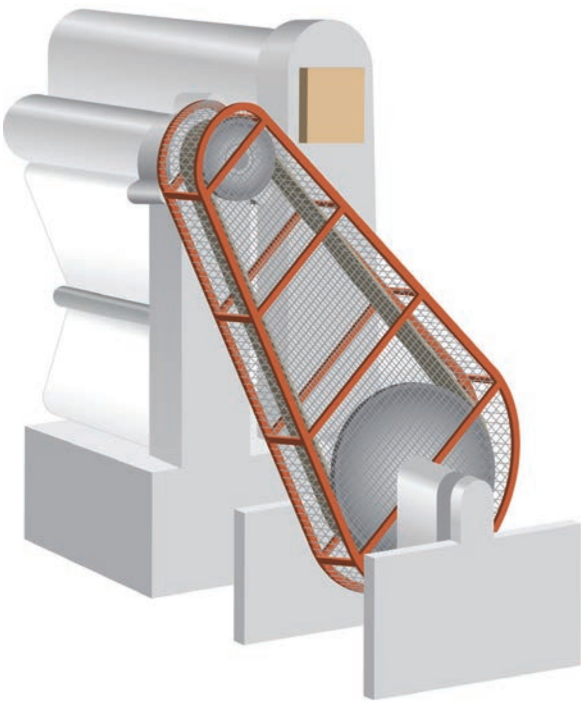
Fixed Guards

A fixed guard is a physical barrier that prevents a person from coming into contact with dangerous moving parts. The guard may by shaped to fit the machine quite closely (enclosing guard), or it may be more like a fence around the machine (perimeter guard). It may have openings in it (e.g. to allow raw material to be fed into a machine), but these must be designed in such a way that it is not possible to reach in and contact dangerous parts (distance guard).

Basic principles of a fixed guard:

- It completely prevents access to dangerous parts.
- It is fixed in place.
- Fixings require a tool for removal – the guard must not be removable by finger force alone.

Fixed guards are often made of sheet metal. If ventilation (e.g. to prevent overheating of machine parts) or visibility into the machine is required, then a mesh guard or perspex guard might be used instead. If a mesh guard is used then care must be taken to ensure that the mesh size is not so large that it allows access to dangerous parts.



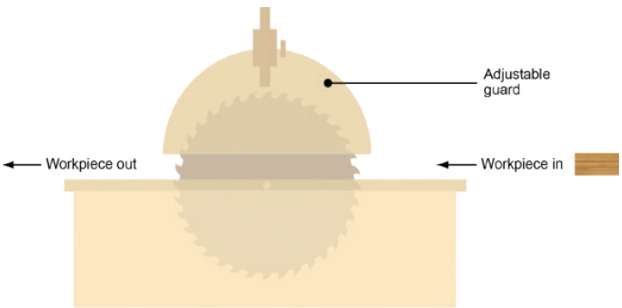
A fixed enclosed guard on a belt-drive mechanism – this guard is made of mesh to allow ventilation and visibility

The main **disadvantage** of a fixed guard is also its main strength - it totally prevents easy access into the machine. There are many situations where easy access into a machine is necessary for machine operation, setting or cleaning. When routine access inside a guard is required, a fixed guard should not be used. If it is, then the operator is very likely to leave the guard off because it is interfering with machine operation.

Adjustable and Self-Adjusting Guards

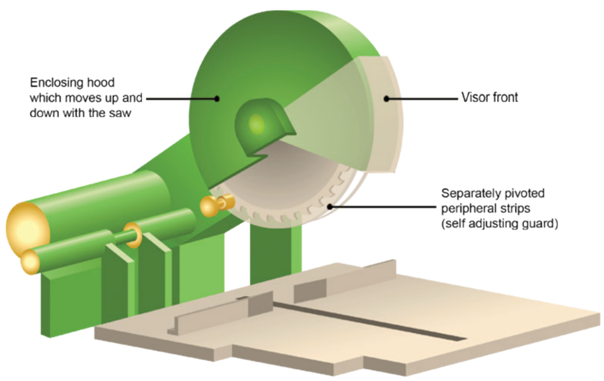
Adjustable and self-adjusting guards are used when it is not possible to completely prevent access to dangerous parts. They are commonly used to safeguard woodworking and metalworking machinery, where a workpiece has to be fed into the machine or manipulated during machine use.

An **adjustable guard** can be set to a range of positions by the operator, depending on the nature of the workpiece and the operation being carried out. For example, the top guard on a bench-mounted circular saw can be set at a range of heights depending on the size of wood being cut.



Adjustable guard over blade of bench-mounted circular saw; the guard covers most of the blade, but a section remains exposed so that wood can be fed through

A **self-adjusting guard** does the same thing but is spring-loaded or linked to other machine parts. As the machine operates, the guard adjusts automatically to fit the workpiece. It does not require the operator to set it to the right position.



Self-adjusting guard on a crosscut mitre saw; as the saw moves down the guard retracts to expose the blade

The main **limitations** with adjustable and self-adjusting guards are they:

- Do not completely prevent access to dangerous parts.
- Are very easy to defeat.
- Rely entirely on operator competence.

Interlocking Guards

An interlocking guard is a **protective device** designed to be removed as a normal part of routine machine operation. The guard is intended to allow frequent access to a machine or danger zone by removing the power source and preventing the equipment from operating while the guard is open. When the guard is removed a safety interlock system prevents machine operation, e.g. a microwave oven has a hinged door on the front to allow easy access and which is interlocked so that power to the microwave generator is shut off when the door is open.

The basic principles of an interlocking guard are:

- Power to the machine is disabled and the machine will not operate until the guard is in place.
- Either the guard is locked shut until it is safe for the guard to open, or the act of opening the guard stops the dangerous parts and disables power.

Many machines (e.g. photocopiers) are fitted with interlocking doors that, when opened, bring the moving parts to an immediate stop. However, some machines cannot be stopped in this way (e.g. domestic washing machines); it is then preferable to use an interlocking guard that locks shut and can only be opened once the danger has passed.

The main **limitation** of an interlocking guard is that it is possible to bypass the system so that the machine can be operated with the guard open. With simple interlock systems this is easily done, but even complex interlock systems can be defeated by a determined person. The dangerous parts or machinery may not be at rest as the equipment is opened, and this may put the operator at risk (though this can be overcome by good design and consideration of "run down" times). It is also possible that a person may gain access to the inside of a machine guard during operation by climbing over the guard, or by the equipment being restarted by a second operator.

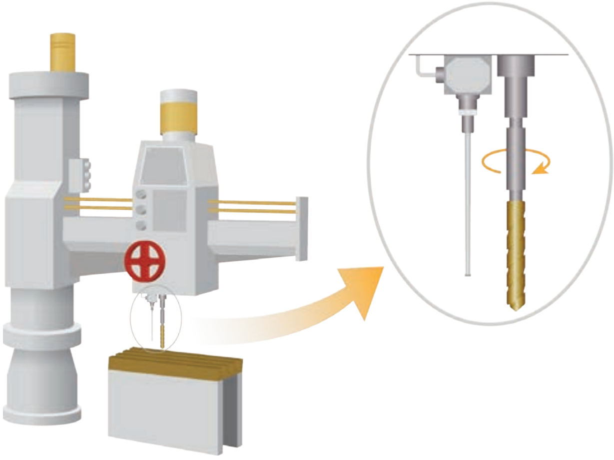
It is, therefore, important that:

- The appropriate type of interlock system is fitted to the machine.
- Strict rules are imposed about safe use of interlocking guards.
- Regular maintenance is carried out.

Control Measures for Reducing Risks from Machinery Hazards

Sensitive Protective Equipment (Trip Devices)

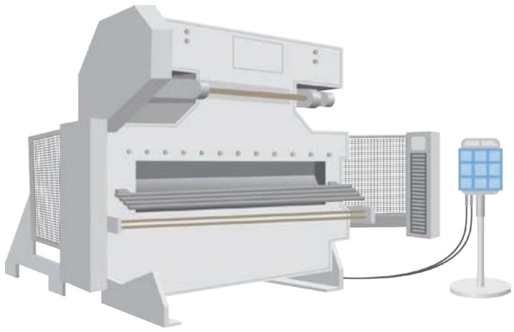
The terms 'sensitive protective equipment' or 'trip devices' cover a range of **protective devices** that do not put a physical barrier between the operator and the dangerous parts of machinery; instead, some form of sensor is used to detect the presence of the operator and stop the machine. Sensitive protective equipment is intended to minimise the severity of an injury and is often used as an additional control measure, e.g. in combination with an interlocking access gate to ensure that an operator does not gain access by climbing over a fence, or is not locked in by a colleague.



Trip bar fitted to a drilling machine; if the bar is hit, the drill emergency stops; note that the bar does not prevent entanglement but simply reduces the severity of injury

There are different types of sensitive protective equipment:

- **Pressure mats** – mats placed on the floor around an item of machinery such as an industrial robot. If a person stands on the mat, their weight activates the trip and the robot stops moving.
- **Trip bars** – wands or rods placed close to dangerous parts which, when touched, will stop machine movement.
- **Photoelectric devices** – shine beams of light across an access point. If the beams are broken then the machine is stopped.



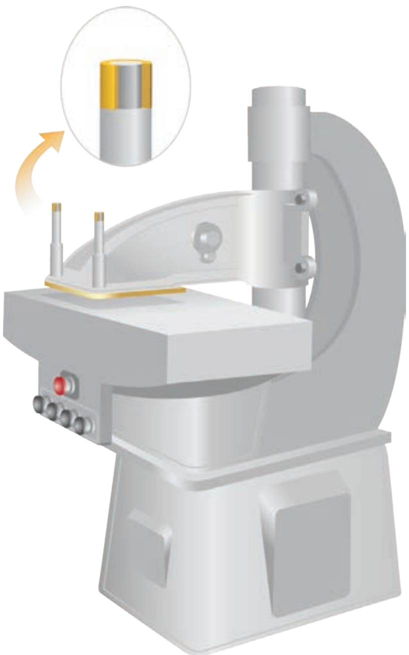
A photoelectric device fitted to a press brake; the device forms a curtain of beams across the front of the machine. (Based on original source L22 Safe use of work equipment (3rd ed.), HSE, 2008 (http://www.hse.gov.uk/pubns/priced/l22.pdf))

The main **limitations** of sensitive protective equipment are that it:

- Does not provide a physical barrier to prevent access.
- Can be over-ridden, e.g. using platforms to span a pressure mat.
- May not operate fast enough to prevent harm (but may reduce the severity).
- May be overly sensitive, leading to frequent trips and production delays, which will encourage the operator to bypass or disable them. Frequent trips may result in operator stress.
- Is more complicated than simple physical guards and may therefore fail more frequently, which encourages misuse.

Two-Hand Controls

These are a way of protecting the machine operator's hands where operation of the machine can only be achieved when two start buttons are pressed at the same time. They are often used when routine machine use requires the operator to put their hands inside or under a machine, where they are at risk from machine operation.



Two-hand controls on a click press;
the operator is at risk of a crushing injury if the press operates when their hand is between the top and bottom plates

The idea is that the machine will only operate when the operator has both hands on the controls.

The important principles of two-hand controls are:

- Controls must be more than one hand span apart (to prevent one-handed operation).
- Controls must have to be activated simultaneously (to prevent the operator jamming one button down permanently).
- Releasing the controls must stop the machine immediately.

The main **limitations** of two-hand controls are that they:

- Do not protect other parts of the body.
- Are relatively easy for two operators working together to bypass the system.

Hold-to-Run Controls

Hold-to-run controls require the operator to hold a control at all times while the equipment or machine is in operation. Releasing the control will disconnect power from the machine and it will cease to function. On some equipment, this may be in the form of a handle or a foot-pedal, and is often referred to as a 'dead-man's handle'.

The important principles of hold-to-run controls are:

- The handle (or pedal) must be held at all times while the machine operates.
- Releasing the control must stop the machine immediately.

The main **limitations** of hold-to-run controls are that they:

- Do not protect any parts of the operator's body.
- Can be easily defeated by the operator.
- Can be held or operated by a person other than the operator.

Emergency Stop Controls

Emergency stops were described earlier in this element. They can be buttons or pull-cords and should be positioned at easily reached positions on the machine and associated control panels.

The key principles of emergency stops are:

- They should bring the machine to a safe stop as quickly as possible.
- They should latch or lock in so that the machine can only be restarted by going to the location of the button to reset it.
- Release of the button should not restart the machine.

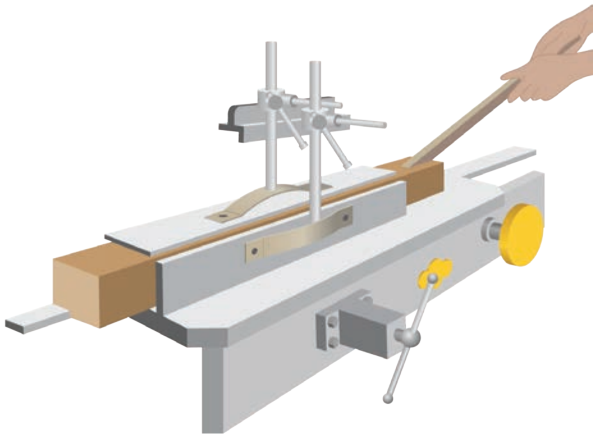
Emergency stop buttons should never be used as a substitute for machine guarding or protection devices. They are intended to provide an additional level of protection in case other safeguards fail.

The main **limitations** of emergency stops are that:

- They are only used once danger has been sensed by the operator and by then it may be too late.
- Despite good design, a person trapped by a machine may not be able to reach the emergency stop.
- It may not be possible to emergency brake the machine quickly enough to prevent injury.

Protective Appliances

Protective appliances are pieces of equipment that allow an operator to keep their hands away from dangerous parts. They include clamps, jigs and push-sticks.



A push-stick is used to push a workpiece through a woodworking machine. The push-stick is simply a piece of wood with a V-shaped notch cut in one end. (Based on original source L22 Safe use of work equipment (3rd ed.), HSE, 2008 (http://www.hse.gov.uk/pubns/priced/l22.pdf))

Personal Protective Equipment

Personal protective equipment (PPE) should only be used as a last resort after other, more reliable, protection options have been exhausted.

Inevitably, though, some of the hazards associated with machinery cannot be designed out or safeguarded by any other means, in which cases PPE becomes appropriate.

A wide range of PPE is available to protect machine operators from one or more hazards associated with the machine that they are operating, e.g. respiratory protective equipment may be used to prevent inhalation of hazardous fumes, dust or mist emitted by the machine.

One item of PPE commonly used by machine operators is eye protection. Safety spectacles, goggles or face visors may be used to prevent impact injury to the eye. Such eye protection must always be selected with reference to the relevant standards.

You will have studied the general limitations of PPE in Unit IGC1; however, one particular issue that is worth noting here is that sometimes the use of gloves is inappropriate because it increases the risk of entanglement or drawing in and may increase the severity of injury that results.

Control Measures for Reducing Risks from Machinery Hazards

Worker wearing PPE

Information, Instruction, Training and Supervision

Appropriate information, instruction, training and supervision must be provided for machine operators. The question of how much information, instruction, training and supervision is appropriate can be answered by considering the level of risk associated with the machinery and by reference to legal standards and codes of practice.

In particular, information, instruction, training and supervision become important where the level of risk is high and it has not been possible to use other controls to safeguard the machinery. So, for example, very little information, instruction, training and supervision are needed when introducing a document shredder into an office because the machine will be very well safeguarded already; simply asking users to read the instruction manual and then checking to ensure that they do not misuse the machine should be sufficient. But for an item of woodworking machinery - where there is the risk of serious injury, and safe use of the machinery is less reliant on fixed and interlocked guards and more reliant on safe operating procedures - far more information, instruction, training and supervision have to be provided.

APPLICATION OF MACHINERY AND EQUIPMENT GUARDING FOR SPECIFIC EXAMPLES

Earlier we discussed the hazards associated with a range of office, manufacturing, agricultural, retail and construction machinery and equipment. Here, we will look at how the safeguarding methods outlined above can be applied to these examples of equipment.

Office Machinery

Photocopier

- Fixed and interlocking guards enclosing all mechanical hazards.
- Routine inspection and portable appliance testing.
- Use in a ventilated room.

Paper Shredder

- Fixed and interlocking guards enclosing mechanical hazards.
- Routine inspection and portable appliance testing.

A typical paper shredder

Manufacturing and Maintenance Machinery

Bench-Top Grinder

- Secure grinder in position.
- Fixed enclosing guards around motor and part of abrasive wheel.
- Adjustable polycarbonate eye-guards over exposed part of wheel.
- Tool rest adjusted to minimise nip-point between rest and wheel.
- Use and setting restricted to trained operators only.
- Eye protection (impact-resistant).
- Hearing protection may be necessary.

- Installation of local exhaust ventilation (LEV) may be required to control dust.
- Routine maintenance, including inspection and portable appliance testing for electrical safety.
- Regular checks of the grinding wheel.
- Regular checks to ensure the correct grinding material has been selected.
- Operators to avoid loose clothing, which may become entangled.
- If used for prolonged periods, job rotation may be appropriate to reduce exposure to noise and vibration.
- Use restricted to trained operators only.

Pedestal Drill

- Fixed guards over motor and drive mechanisms.
- Adjustable (possibly interlocked) guard over chuck and drill bit.
- Clamp to secure workpiece to base.
- Eye protection (impact-resistant).
- Hearing protection may be necessary.
- Routine maintenance, including inspection and portable appliance testing for electrical safety.
- Use restricted to trained operators only.

Agricultural and Horticultural Machinery

Cylinder Mower (Petrol-Driven, Ride-On Type)

- Fixed guards over drive mechanism.
- Safety switch under seat to ensure that driver is in seat before machine will operate.
- Use restricted to trained operators only.
- Hearing protection.
- Refuelling carried out in well-ventilated area.
- Job rotation may be necessary to limit vibration exposure.
- Use restricted for workers who are sensitive to vibration.

Strimmer or Brush-Cutter (Petrol Driven)

- Fixed enclosing guards over motor and drive mechanism.
- Partial side guards fitted around cutter head.
- Safety interlocked throttle trigger to prevent accidental operation of throttle.
- Face and eye protection (impact-resistant).
- Hearing protection.
- Robust gloves, boots (steel toe-cap), trousers and shirt.
- Job rotation may be necessary to limit vibration exposure.
- Harness to support and balance weight of machine.
- Refuelling carried out in well-ventilated area.
- Use restricted to trained operators only.
- Use restricted for workers who are sensitive to vibration.

Chainsaw (Petrol Driven)

- Appropriate PPE (see Topic Focus).
- Fixed enclosing guards over motor and drive mechanism.
- Hand guard for front hand grip.
- Chain brake to stop chain in event of kick back.
- Safety interlocked throttle trigger to prevent accidental operation of throttle.
- Job rotation may be necessary to limit vibration exposure.
- Refuelling carried out in well-ventilated area.
- Use restricted to trained operators only.

TOPIC FOCUS

Personal protective equipment when using a chainsaw:

- Face (visor) and eye protection (impact-resistant).
- Hearing protection.
- Head protection (hard hat) may be necessary.
- Robust gloves.
- Boots with good grip and steel toe-caps.
- Cut-resistant trousers or chaps (trouser covers).
- Robust shirt.


Wearing PPE while using a chainsaw

Retail Machinery

Compactor

- Fixed perimeter guard around loading area and mechanism.
- Interlocked guard to allow access to loading area.
- Routine inspection and portable appliance testing.
- Use restricted to trained operators only.

Control Measures for Reducing Risks from Machinery Hazards

Checkout Conveyor System

- Fixed and interlocked guards on motor and drive mechanism.
- Trip fitted to conveyor to prevent drawing in.
- Routine inspection and portable appliance testing.
- Use restricted to trained operators only.

Construction Machinery

Cement Mixer

- Location of the mixer on firm, level ground.
- Location away from traffic or where traffic is controlled.
- Fixed guards to motor and drive mechanism.
- Routine inspection and portable appliance testing, and use of residual current device (RCD) for electrically powered equipment.
- Safe storage of petrol and control of ignition sources for petrol-powered equipment; avoid use in confined spaces because of emission of exhaust gases.
- Reduction in manual handling or positioning of cement bags close to the equipment.
- Use restricted to trained operators only.
- Hand protection, respiratory protection, overalls and eye protection (splash resistant).
- Hearing protection to reduce noise exposure.

Bench-Mounted Circular Saw

- Fixed guard fitted to motor and bottom of cutting blade.
- Adjustable top guard fitted above blade.
- Riving knife fitted behind blade (prevents the timber from pinching shut on the saw blade after it has been cut – which can lead to the timber being kicked back towards the operator).
- Hearing protection.
- Eye protection (impact-resistant).
- Extraction ventilation or respirator may be necessary.
- Routine inspection and portable appliance testing.
- Use restricted to trained operators only.

REQUIREMENTS FOR GUARDS AND SAFETY DEVICES

Guards and safety devices must be suitable. If they are not, then they will not fulfill their function, the machine may not operate correctly, or the operator may come under pressure to remove or defeat them.

TOPIC FOCUS

Basic requirements of a guard or safety device:

- Suitability for the intended purpose - e.g. if it is intended to also contain dusts, then a mesh guard is unsuitable.
- Meets relevant standards – with regard to preventing contact with dangerous parts, e.g. located at the correct distance from the danger zone.
- Strong and robust - to withstand the forces it may be subjected to, e.g. ejection of parts.
- Compatible – must not interfere with machine operation.
- No rough or sharp edges.
- Not easy to defeat or bypass.
- Vision – must not interfere with any need to see in to the machine.
- Ventilation – must not block any air flow required.
- Ease of maintenance – should be easy to maintain.
- Removal for maintenance – ideally, the guard should not have to be removed to allow maintenance on the machine to take place.
- Does not increase overall risk to the operators.

REVISION QUESTIONS

8. Identify the PPE that should be worn when using a chainsaw.
9. What is the hierarchy of protective measures?
10. Describe the principles of an interlocking guard system.
11. What is a trip device?
12. What are the limitations of adjustable guards?
13. What are protective appliances?
14. When are operators required to be trained in the use of safety equipment?
15. How may two-handed controls be overridden?
16. What are the basic requirements for any guarding system?

(Suggested Answers are at the end)

SUMMARY

This element has dealt with some of the hazards and controls relevant to work equipment.

In particular, this element has:

- Described some of the basic management issues that must be considered when introducing work equipment, such as:
  - Suitability for task and environment.
  - Prevention of access to dangerous parts of machinery.
  - Restriction of use to competent operators.
  - Information, instruction and training.
  - Inspection and maintenance requirements.
  - Marking and positioning of controls.
  - Stability, lighting and space requirements.
  - Operator behaviour.
- Outlined the hazards and precautions associated with simple hand tools, such as hammers and chisels.
- Outlined the hazards and precautions associated with portable power tools, such as a portable electric drill or disc cutter.
- Explained the mechanical hazards of machinery as: crushing; shearing; cutting or severing; entanglement; drawing in or trapping; impact; stabbing or puncture; friction or abrasion; and high-pressure fluid injection.
- Identified the non-mechanical hazards of machinery as: electricity; noise; vibration; hazardous substances; radiation (ionising and non-ionising); extreme temperatures; ergonomics; slips, trips and falls; and fire and explosion.
- Described the hazards associated with photocopiers, shredders, bench-top grinders, pedestal drills, cylinder mowers, strimmers, chainsaws, compactors, checkout conveyors, cement mixers and bench-mounted circular saws.
- Explained the basic characteristics of fixed guards, adjustable and self-adjusting guards and interlocking guards, as well as the characteristics of sensitive protective equipment (trip devices), two-hand controls, hold-to-run controls, protective appliances and emergency stops, as well as the need for provision of PPE and information/training/supervision.
- Outlined the basic requirements of guards and safety devices, such as: must meet relevant standards; be strong and robust; compatible with machine operation; not easy to defeat; allow visibility and ventilation; take maintenance into account; and not increase overall risk.
- Identified which of these types of guards and other protection measures are necessary to ensure safety in the use of photocopiers, shredders, bench-top grinders, pedestal drills, cylinder mowers, strimmers, chainsaws, compactors, checkout conveyors, cement mixers and bench-mounted circular saws.

QUESTION

(a) **Identify** hazards associated with the use of a cement mixer. (4)

(b) For the hazards identified above **outline** control measures that can be used to reduce the risks. (4)

Based on IGC2 March 2012, Question 2

APPROACHING THE QUESTION

Think now about the steps you would take to answer the question:

1. The first step is to read the question carefully. Note that part (b) of this question asks you to outline control measures. An outline is defined as "give the key features of". You need to give a brief description of something, or a brief explanation of reasons why. This is less depth than "explain" or "describe" but more depth than "list". A great amount of depth and detail is not required.

2. Next, consider the marks available. In this question there are eight marks, so it is expected that around eight or nine different pieces of information should be provided. Questions that are split into parts (this one is split into two parts worth four marks each) are often easier to pick up marks on, because the signposts NEBOSH use are so much easier to see. The question should take around eight minutes in total.

3. Now highlight the key words. In this case they might look like this:

   (a) **Identify** hazards associated with the use of a cement mixer. (4)

   (b) For the hazards identified above **outline** control measures that can be used to reduce the risks. (4)

4. Read the question again to make sure you understand it and have a clear understanding of the hazards associated with the use of cement mixers and their control measures. (Re-read your notes if you need to.)

5. The next stage is to develop a plan – there are various ways to do this. Remind yourself, first of all, that you need to be thinking about 'hazards' for the first part; and 'controls' for the second part.

6. The answer plan will take the form of a bullet-pointed list that you need to develop into a full answer, based on the key words that you have highlighted.

Your answer must be based on the key words you have highlighted. So, in this case, we need to identify at least four hazards associated with cement mixers, and outline corresponding control measures to control each one.

Now have a go at the question. Draw up an answer plan, and then use it as the basis to write out an answer as you would in the exam.

Key hint: don't just think of mechanical (machinery) hazards – there are lots of potential hazards associated with the use of a cement mixer.

When you have finished, compare your plan and full answer with those that follow.

SUGGESTED ANSWER

Plan

Cement-mixer Hazards

- Ejection of materials.
- Entanglement in moving parts.
- Chemical hazards (irritant and corrosive).
- Inhalation of dusts.
- Noise.
- Electrocution (if electrically-powered).
- Contact with diesel/fumes if diesel-powered.
- Manual handling.

Corresponding Controls

- Guards to contain contents.
- Guards to prevent access.
- PPE including gloves, goggles, overalls.
- Use of RPE to prevent inhalation.
- Use of ear defenders.
- Maintenance and use of RCD.
- Adequate ventilation, safe storage of fuels.
- Mechanical lifting aids, reduction in cement bag size, training.

POSSIBLE ANSWER BY EXAM CANDIDATE

(a) Hazards associated with the use of a cement mixer include:

- *The ejection of materials from the moving drum.*
- *Contact with moving parts resulting in entanglement or abrasion.*
- *Contact with the corrosive cement and inhalation of irritant dusts.*
- *Noise during the operation of the mixer.*
- *Electrocution from an electrically-powered mixer.*
- *Manual handling of the cement bags.*

(b) Corresponding controls to reduce the risk could include the following. Guards could be installed in order to contain debris and prevent ejection of materials, while also preventing access to moving parts of the mixer. PPE, including gloves, eye protection and overalls could be used to protect from the corrosive cement, while dust masks could be used to prevent inhalation of cement dusts. Maintenance may reduce the noise levels; however, hearing protection, e.g. ear plugs, could be used to further reduce the risk. The risk of electric shock could be reduced by using reduced-voltage (110V) power supplies, or, if this is not possible, an RCD could be used. Finally, manual handling could be reduced by using mechanical lifting aids, reducing bag sizes, using team lifting and providing training in safe lifting techniques.

REASONS FOR POOR MARKS ACHIEVED BY CANDIDATES IN EXAM

As before, bullet points have been used with care in the above example answer – this is not a list, and the correct level of detail for an "identify" question has been used.

Most candidates managed this question well. However, some did lose marks for not providing sufficient detail for an "outline", as required in part (b).

ELECTRICAL SAFETY

ELEMENT 5

LEARNING OUTCOMES

On completion of this element, you should be able to demonstrate understanding of the content by applying what you have learnt to familiar and unfamiliar situations. In particular you should be able to:

1. Outline the principles, hazards and risks associated with the use of electricity in the workplace.
2. Outline the control measures that should be taken when working with electrical systems or using electrical equipment in all workplace conditions.

Contents

Principles, Hazards and Risks Associated With the Use of Electricity at Work

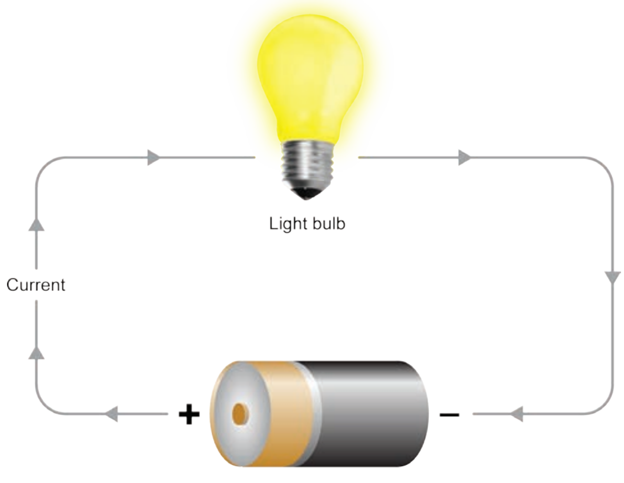
KEY INFORMATION

- A simple electrical circuit can be described in terms of three parameters: voltage, current and resistance. These three parameters are linked by a simple relationship called Ohm's law: V = I x R.
- The hazards of electricity are: electric shock; burns (both direct and indirect); electrical fires and explosions; static electricity, arcing; and secondary effects.
- When a person receives an electric shock they can suffer a range of effects, from mild discomfort and muscle tremor, through uncontrollable muscle contractions and respiratory failure, to ventricular fibrillation, cardiac arrest and severe burns.
- The severity of injury is influenced by several factors, such as: system voltage; duration of contact; pathway through the body; body resistance; contact surface area; environmental factors; and frequency.
- Portable electrical equipment is often involved in electrical accidents because it is frequently unsuitable for the job being done, is misused, and not inspected or maintained.
- High-risk work activities include the use of poorly maintained electrical equipment, work near overhead power lines, contact with underground power cables, work on live supplies and the use of electrical equipment in wet environments.

PRINCIPLES OF ELECTRICITY

Electricity is the flow of electrons through a conductor. A commonly used conductor is copper wire.

For electricity to flow the conductor must be arranged with a power source to make a circuit. A very simple circuit is shown in the following figure, where a battery and a light bulb have been connected together using copper wire to form a loop. Electricity flows in one direction around the circuit, from one terminal of the battery to the other. As it passes through the bulb the filament in the bulb resists the flow of electricity, heats up and emits light. If the wire is disconnected from the battery or bulb the circuit is broken, flow stops and the bulb goes out.



A simple electrical circuit

The basic parameters of an electrical system, such as the circuit shown, are:

- **Voltage** – a measure of the potential difference or electrical driving force/pressure that is forcing electricity through the conductor (unit: volt; symbol: V).
- **Current** – a measure of the rate of flow of electricity through a conductor (unit: ampere or amp; symbol: I).
- **Resistance** – a measure of how much a component in the circuit resists the passage of electricity (unit: ohm; symbol: R).

These three parameters are linked by a simple relationship called **Ohm's law**:

Voltage = Current x Resistance

Volts = amps x ohms

V = I x R

So, if you know two of the parameters of an electrical circuit, you can calculate the third. For example, in our circuit diagram, if the battery is 1.5 Volt and the bulb has a resistance of 5 ohms then the current flow through the circuit will be 0.3 amps (1.5 = 0.3 x 5).

One final characteristic of electrical systems worth considering is the nature of the current flow. In our basic circuit the current flows in one direction only - from one terminal of the battery to the other. This is referred to as **direct current (DC)** and is usual for battery-supplied electrical systems. The mains supply, however, in domestic houses and workplaces, flows forwards and backwards through the circuit and is known as **alternating current (AC)**. The rate at which AC current switches backwards and forwards is called the **frequency** - the number of cycles per second (unit: hertz; symbol: Hz).

The mains electricity supply in different countries around the world varies in terms of both voltage and frequency. For example:

- In the UK it is 230 volts, 50 hz.
- In the USA it is 120 volts, 60 Hz.

HAZARDS, RISKS AND DANGER OF ELECTRICITY

The hazards of electricity are:

- Electric shock – severe electric shock can cause involuntary muscle grip, heart fibrillation, respiratory failure and cardiac arrest.
- Burns – burns can also result from an electric shock, at the point of contact and at the point that the current flows out of the body. There may also be internal burns along the path of the current.
- Fire and explosion.
- Arcing.
- Secondary effects.

Accidents involving electricity frequently involve two or more of these hazards at the same time.

Electric Shock

Electric shock occurs when a person touches a live surface and current passes through their body. Note that the electrical current passes through the body, using the body as a conductor. The current will, therefore, have a pathway through the body, from the point of contact with the live surface (where the current enters the body) to another point of contact with the ground or earthed surfaces (where the electrical current leaves the body). Put simply, the human body can be thought of as replacing the light bulb component in our example circuit.

GLOSSARY

LIVE AND DEAD

When a system is connected to an electrical power source it is described as "live" (in some countries the expression "hot" is used instead). Once it has been disconnected from its power source it might be described as "dead".

When a person receives an electric shock it can have a range of effects. The most important factor that determines what the effects will be is the amount of current (amps) that flows through the body. The following table indicates the range of effects that might be experienced at different current flows.

Current (mA) flowing through the body	Effect
0.5 - 2	Threshold of sensation.
2 - 10	Tingling sensations, muscle tremor, painful sensations.
10 - 60	Muscle contractions, inability to let go, inability to breathe.
60 and above	Ventricular fibrillation, cardiac arrest, extreme muscle contractions, burns at contact points and deep tissues.

The effects of current flow on the body during an electric shock. Note that the current is the current flowing through the body.

(**Note**: in the table above the current is measured in milliamps (mA). One milliamp is one thousandth of an amp (1 mA = 0.001A). The current is AC.)

- At very low current flow (less than 0.5 – 2 mA) no sensation is felt by the person receiving the shock.
- Between 2 and 10 mA current starts to flow through the body and stimulates muscles to contract. This can be felt, it causes muscles to tremble and it may hurt - but the person receiving the shock is able to control their muscles and can let go of the live object.
- Between 10 and 60 mA current starts to cause more severe muscle contractions; these may become so strong that the person cannot control their muscles and they grip on to the live object. When this occurs the muscles of the rib cage and abdomen may contract so that the person cannot breathe (which means that they cannot call for help) and they may asphyxiate. Alternatively, the shock may cause a massive contraction of big muscle groups so that the person is thrown violently off their feet (hopefully away from the live object).

- At current flows above 60 mA there is the possibility of ventricular fibrillation (VF), where the heart is no longer beating in a synchronised, rhythmic manner but spasmodically (i.e. in an erratic way). This usually leads to cardiac arrest. As the current increases above 80 mA the possibility of VF becomes greater. Muscle contractions can become so extreme that bones are broken, burns will occur at the entry and exit points and in the tissues that the current has passed through. Death becomes more likely as the current increases.

TOPIC FOCUS

Several factors influence the severity of injury associated with receiving an electric shock:

- **Voltage** – as Ohm's law shows, there is a simple relationship between voltage and current: the higher the voltage, the greater the current.
- **Duration** – the length of time that a person is exposed to the flow of electricity is critical. For example, a current flow of 60 mA for 30 milliseconds (30 thousandths of a second) is unlikely to cause a severe injury, whereas the same current flow over a period of two seconds can induce VF and prove fatal.
- **Frequency** – of the AC current.
- **Current path** – the route that the electricity takes as it flows through the body is also critical. If it runs through the chest it is likely to affect the heart.
- **Resistance** – as Ohm's law shows there is a simple inverse relationship between current and resistance: the higher the resistance, the lower the current. Most of the body's resistance to the passage of electricity is because of the skin. A person with **dry skin** has a resistance of about 100,000 ohms, but if their skin is **wet or damaged** this reduces dramatically to 1000 ohms. Any clothing that the person is wearing will also affect their resistance to the passage of electricity.
- **Contact surface area** – the more skin that is in contact with the live surface, the lower the resistance and the more severe the injury.
- **Environment** – any environmental factors that reduce resistance will cause an increase in current flow and therefore increase the severity of the shock, e.g. wet surfaces, humid air, metal surfaces, etc.
- **Nature of the clothing and footwear** – may provide some protection.
- **Presence of potential secondary hazards** – can result in additional injuries, e.g. if working off a ladder the person may fall.

To illustrate the effect of the factors listed above, consider two separate scenarios:

Scenario 1

A person has one hand on a live part (voltage = 230 V) and is standing in a puddle of water with socks on. Their hand-to-ground resistance is 1000 ohms.

Using Ohm's law:

V = I x R

230 = 0.230 x 1000

So, the current that flows through them will be 0.23 amps, or 230 mA.

Using the table given earlier you can see that this current flow will be associated with VF, cardiac arrest and severe burns. This will probably be a fatal electric shock (unless the power is disconnected very quickly).

Scenario 2

A person has one hand on a live part (voltage = 110 V), is fully clothed and booted and is standing on a dry floor. Their hand-to-earth resistance is 100,000 ohms.

Using Ohm's law:

V = I x R

110 = 0.0011 x 100,000

So, the current that flows through them will be 0.0011 amps or 1.1 mA. Using the table, you can see that this current flow will be associated with the threshold of sensation, i.e. an effect is likely to be felt.

The main differences between these two scenarios are the voltage and the resistance (which has been influenced by clothing and environment); these two factors make an enormous difference to the severity of outcome.

Electrical Burns

People receive burns in two different ways during electrical accidents:

- **Direct electrical burns** – where current causes overheating as it passes through the skin and the internal tissues of the body. There may be entry and exit skin burns and these will be full skin thickness. Internal tissue burns can be very severe and may prove fatal.
- **Indirect electrical burns** – which do not occur as a result of current passing through the body, but when an electrical accident causes something to overheat and explode. For example, dropping a spanner onto a high-voltage cable can cause a short circuit, resulting in a flash of radiant heat and an explosion of molten metal.

Electrical Fires

Electricity can cause fires in several different ways:

- Electrical equipment may be faulty and may overheat as a result, leading to a fire.
- The system may be overloaded; as too much current passes through, it overheats.
- Equipment may be misused, e.g. it may be connected into the mains supply by pushing bare wires into the socket rather than using the proper plug.
- A flammable atmosphere may be present, which is ignited by electricity. This can happen in two different sets of circumstances:
  - The wrong type of electrical equipment is brought into an existing flammable atmosphere (i.e. one which is already known to be flammable).
  - A flammable atmosphere is accidentally created in an area where it would not be expected (e.g. due to spillage).
- Electrical equipment may produce heat or sparks as part of its normal operation. For example, a fan heater gets hot during use; if poorly positioned next to a full wastepaper bin, it may start a fire.

One common cause of overheating electrical equipment is poor internal connections. When two electrical components are joined together the connection between them must be well made and secure. A poor connection causes an increased resistance, which, in turn, leads to overheating at the connection point. Poor connections can occur because the connection was not properly made when the equipment was being manufactured or installed, but they can also occur as a result of the loosening of parts over time. Fixed installations – such as distribution boards – can suffer this type of failure.

Static Electricity

Static electricity is different to the battery and mains supply electricity that we have discussed so far. Static electricity refers to the build-up of potential difference (voltage) between surfaces as a result of friction between them. For example, if a person walks across a new carpet and scuffs their feet they may get a small static shock when they touch a door handle. This is because they have built up a voltage on their body through the friction between their shoes and the carpet. This voltage has then been discharged in a very short-duration spark.

Little risk exists to a person from the normal static shock found in most workplaces, unless there are flammable liquids or flammable atmospheres present. There is then the risk that the static shock will ignite the liquid or atmosphere, causing fire or explosion.

Arcing

Arcing is where electricity jumps across an air gap. It occurs in a very limited way inside some low-voltage electrical equipment (e.g. a portable electric drill).

The dangers associated with arcing increase at higher voltages because the distance that electricity can arc through air is determined primarily by voltage: the higher the voltage, the greater the distance. High-voltage power lines can arc across distances of more than 10 metres through air.

The main risks associated with arcing are:

- Electric shock as a result of being struck by the arc.
- Direct burns as a result of being struck by the arc.
- Indirect burns from the radiant heat given off by the arc and from the melting of any equipment struck.
- Damage to the eye as a result of the ultraviolet light (UV) that is emitted by the arc.

Workplace Electrical Equipment

A wide variety of workplace equipment is operated by electricity, including:

- Equipment that is 'hard-wired' directly into fuse or distribution boards and distribution systems, such as bus-bars. Hard-wired equipment still needs to be inspected and tested (see later) to ensure connections and system components remain secure and operational, particularly cables that may be exposed to pedestrian and vehicle traffic, but it is less likely to undergo the rigours of being unplugged and moved around the workplace.
- Portable appliances. Portable electrical equipment can be defined as equipment with a cord and plug on it that can be moved from one location to another for use. (Whether it actually is moved is irrelevant; a photocopier may never be moved but it has a cord and plug and is, therefore, portable.) A high proportion of electric-shock accidents involve portable electrical equipment.

  As an example of vulnerable portable electrical equipment, consider a small concrete breaker used on a construction site. It is:

  - Subject to frequent heavy use in an outdoor environment.
  - Often handled and transported.
  - Used by a variety of users who may not own the item and therefore have little interest in taking care of it.

The same hazards apply to these types of equipment, but the risks can be different, especially with portable appliances.

TOPIC FOCUS

Conditions and practices likely to lead to accidents:

- Using unsuitable equipment, e.g. the use of non-intrinsically safe equipment in a flammable atmosphere.
- Using equipment in wet, damp or humid conditions.
- Misuse, e.g. sticking wires directly into a socket rather than using a plug.
- Physical abuse, e.g. pulling the plug out by tugging at the cord; carrying the tool by the cord; allowing the cord to be pinched, trapped or crushed, driving over the cord, etc.
- Inadequate maintenance or repairs carried out by unauthorised personnel, or carried out badly, e.g. a split cord taped up with insulating tape.
- Continued use of faulty, defective equipment.
- Chemical damage to the cord, e.g. by corrosive wet cement.
- Physical damage to the cord by hostile environments.
- Lack of routine inspection, testing or maintenance.

Secondary Effects

Any sort of injury that results indirectly from receiving an electric shock is a **secondary effect**.

Common secondary-effect injuries occur when people undergo violent muscle contractions during an electric-shock accident. They may be thrown across a room and receive cuts, bruises and broken bones as a result. If they happen to be working at height off a ladder, then even a relatively minor shock can cause enough of a reaction to lead to a fall.

Use of Poorly-Maintained Electrical Equipment

Portable electrical appliances or fixed installations that are not maintained and inspected can easily fall into disrepair. Workers may be unaware of these faults, or they may be aware of the faults but still continue to use the equipment. This results in increased risk of electric shock, fire, etc.

Principles, Hazards and Risks Associated With the Use of Electricity at Work

Work Near Overhead Power Lines

Most overhead power lines are uninsulated (bare conductors). Because of this, any work carried out near to these power lines has a risk of electrical arcing (see earlier). The distance that the arc can jump will depend on the voltage of the electrical system and environmental factors, such as air humidity.

Work near overhead power lines involves the risk of electrical arcing

Contact with Underground Power Cables

Striking buried power cables is a significant risk associated with excavation work (see Element 1). It can lead to electric arcing, shock and burns, not to mention major business disruption to service users.

Work on Mains Electricity Supplies

Any work on or near exposed live mains supply conductors is inherently high risk because of the severity of injury that might result in the event of an accident. As an example, mains electricity supplies in the UK operate at 230V.

Use of Electrical Equipment in Wet Environments

Because water decreases the resistance of objects and environments to the passage of electricity, any work using electrical equipment in wet environments increases the risk. Not only are electric shock accidents more likely to happen in these conditions (because materials that normally insulate will start to conduct) but the severity of injuries received can be greater (because lower resistance means higher current flow).

MORE...

http://www.hse.gov.uk/electricity/index.htm

TOPIC FOCUS

Control measures to be considered when selecting portable electrical equipment for use on construction sites:

- Use battery-powered equipment.
- Use reduced and low-voltage (110 V) equipment that is centre-tapped to earth.
- Provide increased protection through the use of an RCD (Residual Current Device).
- Locate cables carefully, away from hazards, e.g. vehicles that may drive over them.
- Use double-insulated equipment.
- Carry out pre-use checks of the equipment for signs of damage.
- Train operators in safe use of the equipment.
- Avoid using in wet conditions (unless the equipment and supply cables are suitable for this).
- Implement a programme of routine visual inspection and thorough testing of electrical equipment and cables.

REVISION QUESTIONS

1. What is the relationship between current, resistance and voltage in a simple circuit?
2. What are the main effects of electric shock on the body?
3. If a person receives a shock for one second, which passes through the body along a path with a resistance of 10,000 ohms, what would be the current received and what effect might it have on the person if the voltage of the circuit touched was:

   (a) 230 volts.

   (b) 110 volts.

   (c) 50 volts.
4. What is arcing and what risks does it pose?

(Suggested Answers are at the end.)

Control Measures

KEY INFORMATION

- Electrical equipment must be carefully selected to ensure that it is suitable for the electrical system, purpose and environment of use.
- Various protective systems can be used for electrical equipment, such as:
  - Fuses – a weak link in the circuit – or miniature circuit breakers.
  - Earthing – a low-resistance path to earth for fault current.
  - Isolation of supply– cutting the power.
  - Double insulation – separating people from the conductors using two layers of insulation.
  - Residual current devices – sensitive and fast-acting trips.
  - Reduced and low-voltage systems – so that less current flows during an electric-shock accident.
- Each of these protective systems has advantages and limitations.
- Work on electrical systems should be restricted to competent persons only.
- Safe systems of work should be used when risk is created by work on or near electrical systems.
- Workers should be aware of the emergency procedures to be used following an electrical incident.
- All electrical installations, equipment and appliances should be subject to user checks, formal visual inspections and combined inspection and testing to ensure electrical safety.

PROTECTION OF CONDUCTORS

Electrical conductors should be protected by insulation so that a person is not exposed to a live conductor. For example:

- Cables should be insulated by an unbroken, undamaged sheath so that the live copper conductors are never exposed.
- The casing on a drill should be intact so that the user cannot make contact with the live components within.

It is essential that equipment is inspected and maintained to ensure that the insulation and protective layers are not damaged, and that where access may be possible (e.g. via an electrical panel or switchgear) the access doors are locked and controlled.

STRENGTH AND CAPABILITY OF EQUIPMENT

Electrical equipment must be carefully selected to ensure that it is suitable for:

- The electrical system that it will become a part of.
- The task that it will perform.
- The environment in which it will be used.

No electrical equipment should be put into use where its electrical **strength and capability** may be exceeded and give rise to danger. It should be able to withstand normal, overload and fault currents. It should also be used within the manufacturer's rating and in accordance with any instructions supplied. This may require reference to electrical specifications and tests undertaken by the manufacturer and accredited testing organisations, based on international and national standards.

If the equipment might be exposed to hazardous environments, then it should be constructed and protected to prevent danger. The following hazardous environments should be taken into account:

- Weather – equipment and cables may need to withstand exposure to rain, snow, ice, wind, dust and lightning.
- Natural hazards, e.g. solar radiation, plants and animals (e.g. gnawing of cables by rats).
- Extremes of temperature and pressure, e.g. heat from motors.
- Dirty conditions – contamination by liquids or solids.
- Corrosive conditions – caused by chemicals.
- Liquids and vapours – immersion, splashing or spraying with water and solvent vapours, etc.
- Flammable substances, e.g. flammable gases, dusts and vapours.

Foreseeable mechanical damage must also be considered, both in terms of the environment within which the equipment is to be used and the natural operation of the equipment itself. For example, abrasion may be caused by mechanical movement, leading to damage of the cord; this might be prevented by using an armoured cord.

ADVANTAGES AND LIMITATIONS OF PROTECTIVE SYSTEMS

Fuses and Miniature Circuit-Breakers

A **fuse** is a device used to prevent current overload. A simple fuse is made up of two metal caps joined by a thin piece of fuse wire. When this fuse is incorporated into an electrical circuit, current flows through the wire. If the current is too great for the fuse wire rating, the wire becomes hot and melts. This breaks the circuit.

Advantages of fuses:

- Very cheap and reliable.
- Offer a good level of protection for the electrical equipment against current overload that might damage the equipment, or cause overheating, fire or explosion.

Limitations of fuses:

- They primarily protect equipment and not people. It is possible to receive a severe, even fatal, electrical shock from equipment that is protected by a fuse for two reasons:
  - A fuse does not stop current flow quickly enough to prevent ventricular fibrillation.
  - The current flow must be above the fuse rating for the fuse to operate; this may be above the 60 mA capable of causing fatal injury.
- Very easy to bypass, e.g. by wrapping the fuse in aluminium foil.

Miniature circuit-breakers (MCBs) are electromechanical devices that work in a similar way to fuses to protect equipment from current overload. One significant difference is that an MCB does not melt in response to current overload; it simply trips out and can be reset by pressing a button. This is the main **advantage** of MCBs - they do not have to be removed in order to be reset, so they are more tamper-proof than fuses. Otherwise, the **limitations** of MCBs are similar to those for fuses.

Earthing

Earthing is a way of protecting equipment so that in the event of an electrical fault, current flows safely to earth rather than flowing through a person who might be touching the equipment. The earth wire of an item of electrical equipment is usually connected to the outer metal casing or chassis of the equipment. If a fault develops and the casing or chassis becomes live then a current will flow down this earth wire. Electricity always takes the path of least resistance, and since the earth wire will have very low resistance the majority of fault current will flow safely to earth through the wire. Any person touching the casing will receive a minor shock.

Advantages of earthing:

- It protects the person from fatal electric shock.
- It often provides secondary protection to the equipment because a large fault current flowing to earth will overrate the fuse or MCB.

Limitations of earthing:

- A poor or broken earth connection will prevent the earth from working properly, but since the earth wire does not take part in the normal functioning of the equipment this fault can go completely undetected.
- It is easy to disconnect and disable.

Isolation of Supply

Isolation is the removal of electrical power from a circuit or system. This might be achieved using a switch (isolator) or by pulling the plug out. This makes the system or circuit dead and safe to work on (unless electrical energy is stored in the system).

To ensure safety, isolation should always be physically secured before people work on the dead system. This is often achieved by padlocking isolators in the off position (the lock-out/tag-out system). As an additional precaution the system should then be tested to prove that it is dead (and the test meter used should itself be tested both before and after this proof has been carried out).

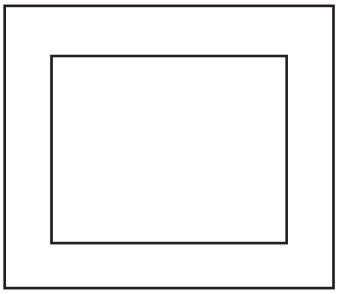
An electrician using the lock-out/tag-out system

The **advantage** of isolation as a form of protection is that it is a very effective method of ensuring that people cannot be injured by electrical energy when working on an electrical system.

The **limitation** of isolation is that, by definition, the electrical system is dead. Certain types of testing, fault finding and electrical installation and repair work have to be carried out with the electrical system on and live. Isolation cannot be used in these circumstances.

Double Insulation

The principle behind double insulation is exactly as the name suggests: there are two layers of insulation between the user and any live conductors. This eliminates the need to provide earth protection, so double-insulated equipment will have a two-core cord: live (hot) and neutral only. Double insulation is commonly used as the means of protection for hand-held portable electrical equipment, such as hedge-trimmers.



This symbol is displayed on double-insulated equipment

The **advantage** of double insulation is that it relies on insulation rather than the electrical system itself for safety.

The **limitation** of double insulation is that the insulation must be routinely visually inspected because there is no earth protection.

Residual Current Devices

A residual current device is specifically designed to protect human life in the event of electric shock. It does this on the basis that it is very sensitive to small current imbalances in a circuit and is able to break the circuit very quickly.

The principle of an RCD is that it constantly compares the amount of current flowing down the live (hot) and neutral lines and trips the circuit if an imbalance is detected. RCDs (and earth leakage circuit-breakers (ELCBs), which work on a similar basis) can be:

- Incorporated into electrical equipment (as part of the plug).
- Stand-alone devices placed between a portable appliance plug and the power socket.
- Hard-wired into distribution systems such as the "consumer unit" of a domestic house (which, in many countries, has become standard practice for new or rewired houses).

The **advantage** of RCDs is that they provide excellent protection for people from electric shock.

The **limitations** of RCDs are that they:

- Do not provide over-current protection (they are not fuses; they work on a completely different principle).
- Have to be tested periodically (this is often not done).
- Can cause repeated circuit tripping if there is a fault; this can encourage people not to use them, or to disable them.

Reduced and Low-Voltage Systems

The lower the voltage at which an electrical system is operated, the lower the risk of injury associated with electric shock. This is because of the relationship that exists between voltage and current, as indicated by Ohm's law. As voltage is reduced, so the shock current is reduced and the severity of injury reduced.

Countries (such as the UK) that operate on a 230 V mains supply often make use of transformers to step the voltage down to 110 V for portable power tools. In the UK this is standard practice on construction sites; all portable electrical tools operate at 110 V or less. Systems that operate at even lower voltages can be used (e.g. 50 V). Very low-voltage systems (such as 12 V) present very little risk of electric shock injury.

The **advantage** of low voltage systems is that the system is inherently safer.

The **limitation** is that low-voltage systems are inefficient at transmitting power and therefore cannot be used for many industrial applications.

COMPETENT PERSONS

Where work on electrical systems creates danger or risk of personal injury, the employer must restrict that work to those people who have the necessary technical knowledge or experience to be able to carry out work safely. In this context a competent person has:

- Knowledge of electricity.
- Experience of electrical work.
- An understanding of the system to be worked on.
- An understanding of the hazards and the precautions needed.
- The ability to recognise whether it is safe for work to continue.

The extent of personal knowledge and experience needed will have to be decided by the employer. It may be that these requirements can be relaxed, provided that an adequate level of supervision is being applied (e.g. an apprentice electrician can gain experience as long as they are appropriately supervised).

SAFE SYSTEMS OF WORK

Safe systems of work (SSW) must be developed when work on or near electrical systems creates risk. There are several issues that might be considered here:

- **Work On or Near Live Electrical Systems**
  Work must not be carried out on or near live electrical systems except in very particular circumstances, and there may be national laws governing live work. Live work should be prohibited in most instances. Where live work is justified (because there is no alternative) then there must be a SSW in place to ensure that the live work can be carried out safely. This SSW is likely to make use of the following controls:
  - Permit-to-work system.
  - Competent persons.
  - Insulating PPE (such as gauntlets and boots).
  - Insulated tools and equipment (such as screwdrivers).
  - Designated work areas (such as "earth-free zones").
- **Isolation**
  Most work on electrical systems should be carried out with the system dead. This requires that the system is isolated from its source of electrical power. As we noted earlier, this isolation usually requires:
  - The breaking of the circuit.
  - Physical securing of the break in the circuit.
  - Some form of label (or tag).

So, for example, the isolator switch for an item of equipment might be switched to the off position, a padlock introduced to secure the isolation and a tag added to identify the worker and the nature of the work activity.

- **Locating Buried Services**
  In Element 1, we looked at the risks associated with accidentally striking buried electricity power cables, and the precautions that should be taken to locate and identify buried services.
- **Contact with Overhead Power Lines**
  As discussed earlier in this element, since most overhead power lines are uninsulated, danger is created if the power line is touched, or if any conducting material is positioned close enough for electricity to arc across. This might be the case during routine work in any workplace, but this issue is particularly associated with construction work.

  Accidents associated with proximity to live overhead power cables can be prevented by:
  - **Isolating** the power supply when working near power lines. If power cannot be isolated, it may be possible to **sleeve** (cover) low-voltage power lines.
  - Using **SSW and permit systems** to control access into danger areas.
  - Using **barriers, signage and goal-posts** to keep plant and vehicles a safe distance from power lines.
  - Using **banksmen** when plant is manoeuvring near power lines.
  - Using **non-conducting equipment**, such as fibreglass ladders.

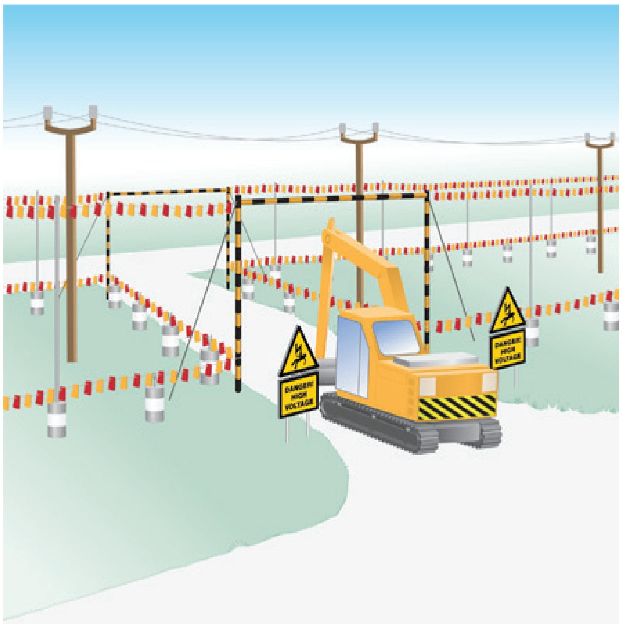


Diagram showing use of barriers, bunting and goal-posts to control proximity of plant to overhead power lines (Based on original source HSG144 The safe use of vehicles on construction sites (2nd ed.), HSE, 2009 (http://www.hse.gov.uk/pubns/priced/hsg144.pdf))

EMERGENCY PROCEDURES FOLLOWING AN ELECTRICAL INCIDENT

If, in spite of all the available control measures being in place, an electrical incident occurs in the workplace, all workers should be aware of the following method for dealing with an electric-shock casualty:

- Do not touch them.
- Call for help.
- Switch them off (turn off the power supply).
- Call for an ambulance.
- If they cannot be switched off then carefully push or pull them away from the live part using non-conducting material, such as timber or dry clothing.
- Check breathing:
  - If breathing, place in the recovery position.
  - If not breathing, apply cardiopulmonary resuscitation (CPR).
- Treat any obvious burns.
- Treat for physiological shock.
- Make sure they get professional medical treatment (heart problems and internal burns may not be apparent to the casualty, or the first-aider).

Careful assessment of the situation when approaching the casualty is important for two reasons:

- The casualty may still be receiving an electric shock, in which case touching them will involve their potential helper in the shock as well.
- High-voltage conductors can arc electric current through the air over large distances (more than 10 metres).

INSPECTION AND MAINTENANCE STRATEGIES

Electrical installations and equipment should be routinely inspected to ensure electrical safety – this includes:

- Electrical equipment installed in buildings, such as the power distribution circuits and lighting.
- Larger equipment that is not moved.
- Smaller, portable appliances.

There may also be national requirements governing the inspection of the electrical installations, or requirements imposed by insurance companies. In many cases tests may also be required to verify the safety of the systems, equipment and appliances in use.

There are several types of inspection and test procedures that might be appropriate for **portable electrical appliances**, which we will now look at in some detail.

User Checks

Some items of electrical equipment should be visually inspected by the user routinely before use. This is particularly important for portable electrical equipment that is used in environments where damage can easily occur (such as a power tool used on a construction site).

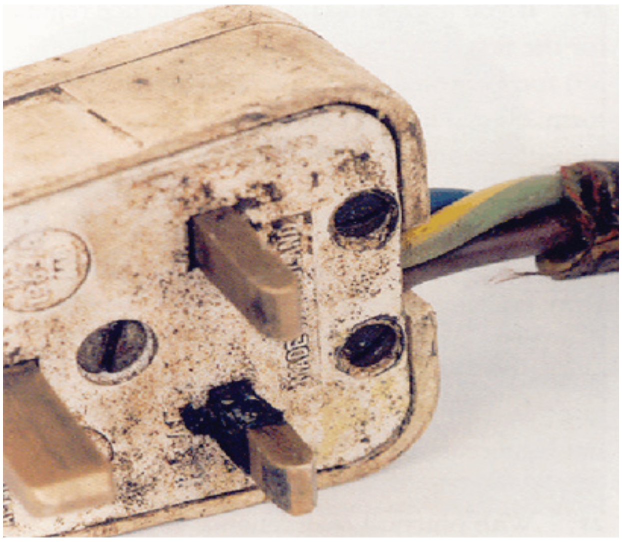
This user check does not involve any form of dismantling, just careful visual inspection of the equipment. If visual inspection or tests show that the equipment is unsafe, then it must be taken out of service and repaired or discarded.

Initially, the equipment should be checked for suitability to ensure that it is appropriate for the task in hand, and that the equipment conforms to the relevant standards, e.g. CE-marked if it will be used in Europe.

TOPIC FOCUS

Things to check during routine visual (user) inspection of a portable appliance:

- Body of plug is intact and secure.
- Outer sheath of cord covers the inner cores all the way into body of the plug and appliance.
- Plug cable clamp appears to be tight.
- Cord appears fully insulated, with no splits or severe kinks/pinches.
- Body of appliance is intact.
- Appliance cable clamp appears to be tight.
- No obvious scorch marks to plug or appliance body.
- Plug and appliance are not excessively soiled.
- Plug and appliance are not wet.

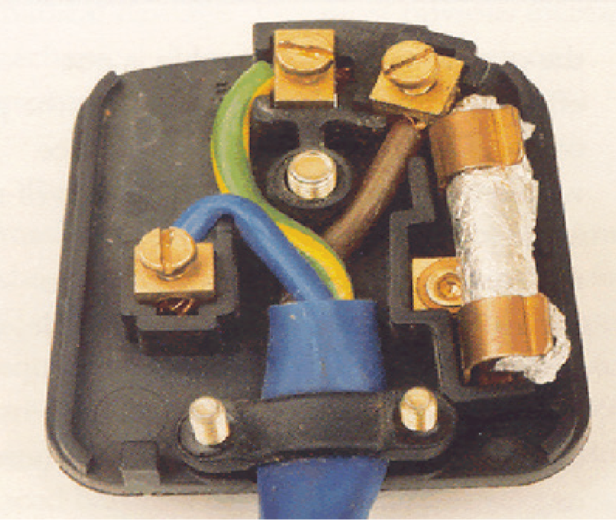


A user check will identify this unsafe condition; the outer sheath of the flex should be securely clamped by the cable clamp inside the body of the plug. Source: HSG107 Maintaining portable and transportable electrical equipment (2nd ed.), HSE, 2004

Formal Visual Inspection

Routine user checks should be backed up with less frequent formal visual inspections in some instances. These formal checks verify that the equipment appears to be in a safe condition. Formal visual inspection often requires dismantling of the equipment, usually the plug, to check that connections are still secure and that the correct fuse is fitted.

Formal visual inspection should be carried out by a competent person, i.e. someone with the appropriate training, knowledge and experience.



Formal inspection should uncover unsafe conditions, such as this fuse, which has been disabled by wrapping it in aluminum foil.
Source: HSG107 Maintaining portable and transportable electrical equipment (2nd ed.), HSE, 2004

Combined Inspection and Testing

The main **limitation** of visual inspection is that there are certain unsafe conditions that can arise with electrical equipment that cannot be detected visually. Deterioration of the insulation and defective earth pathway are two of these unsafe conditions.

Therefore, in many instances, it is appropriate to carry out routine combined inspection and testing to verify the safe condition of electrical equipment. The visual inspection element of this combined inspection and testing is usually the same as the formal visual inspection we have already outlined. The testing element often consists of plugging a portable electrical appliance into a portable appliance test meter which runs the tests automatically. On other occasions, testing requires a detailed technical understanding of the equipment. In any event this must be carried out by a competent person (with appropriate knowledge, training and experience).

Frequency of Inspection and Testing

The frequency at which user checks, formal visual inspections and combined inspection and testing should be carried out will vary, depending on various factors.

For example, in the UK a 110 V hand-held power tool intended for use on a construction site should be visually checked by the user once a week, formally visually inspected once a month, and given a formal combined inspection and test once every three months.

It is common practice to fix a test sticker or label to an item after inspection or testing to indicate when the next inspection or test is due, and retain a register of the test results. In order to achieve this it may be necessary to give each item of equipment an identification number. Controls will also be needed to ensure that unauthorised electrical equipment is not brought into the workplace and put into use without being registered and tested – equipment as simple and commonplace as a kettle has been responsible for workplace fatalities.

Records of Inspection and Testing

Records should be kept of formal visual inspections and tests as proof of completion, so that a history of condition and defects can be maintained for future reference.

Formal records should be kept of all maintenance programmes, showing the periods for inspection and testing. Records of the findings and work carried out should also be kept. Checking systems should be regularly monitored to ensure inspections and tests are completed on time and that any rectifications or replacements are carried out appropriately.

These records often form an inventory of items, especially portable appliances. Trends can be monitored to ensure that the correct items of equipment are selected and used in the right places, and regular incidents of fault or breakdown can indicate correct selection and use. For portable appliances, formal records are often supported with tags, labels and colour-coding of items to indicate conformity with the inspection and testing regime.

Advantages and Limitations of Portable Appliance Testing

Advantages:

- Detection of faults not visible to the eye.
- Early removal/repair of unsafe equipment.
- Demonstration of legal compliance.
- Trends or patterns of faults may be spotted.

Limitations:

- Provides proof of safety at one moment in time only.
- Does not ensure safe use or prevent misuse.
- Items may be missed and then remain untested.
- Cannot be applied to all equipment (e.g. computers).

A portable-appliance test meter
Source: HSG107 Maintaining portable and transportable electrical equipment (2nd ed.), HSE, 2004

MORE...

Further information about electrical safety at work is available from the UK Health and Safety Executive (HSE):

http://www.hse.gov.uk/electricity/index.htm

TOPIC FOCUS

Factors that influence the frequency of inspection and testing:

- Legal standards and codes of practice.
- Type of equipment and whether or not it is hand-held.
- Manufacturers' recommendations.
- Initial integrity and soundness of the equipment.
- Age of the equipment.
- Working environment in which the equipment is used (such as whether it is wet or dusty) or the likelihood of mechanical damage.
- Frequency and duration of use.
- Foreseeable abuse of the equipment.
- Effects of any modifications or repairs to the equipment.
- Analysis of previous records of maintenance, including both formal inspection and combined inspection and testing.

REVISION QUESTIONS

5. What does earthing do?
6. What is the difference between a fuse and a circuit-breaker?
7. What is the difference between switching off and isolation?
8. What protection is offered by a reduced or low-voltage transformer used to provide power to hand tools?
9. What safety device should be used when mains-supplied electric hand tools are being used outdoors?
10. What user checks should be carried out before an item of electrical equipment is used?

(Suggested Answers are at the end.)

SUMMARY

This element has dealt with some of the hazards and controls relevant to the use of electricity in the workplace.

In particular, this element has:

- Outlined basic electrical principles such as voltage, current and resistance, and the relationship between the three: Ohm's law (V = I x R).
- Described the hazards of electricity as electric shock, burns (both direct and indirect), electrical fires and explosions, static electricity, arcing and secondary effects.
- Explained the range of effects of electric shock - from mild discomfort and muscle tremor, through uncontrollable muscle contractions and respiratory failure, to ventricular fibrillation, cardiac arrest and severe burns - and how the severity of injury is influenced by several factors, such as: system voltage; duration of contact; pathway through the body; body resistance; contact surface area; environmental factors; and frequency.
- Outlined the reasons why portable electrical equipment is often involved in electrical accident - because it is often unsuitable for the job being done, misused, and not inspected or maintained - as well as outlining the hazards associated with other activities, such as work near overhead power lines or underground power cables, work on mains electricity supplies, and use of electrical equipment in wet environments.
- Described the various protective systems that can be used for electrical equipment, such as: fuses (a weak link in the circuit) and miniature circuit-breakers; earthing (a low-resistance path to earth for fault current); isolation (cutting the power); reduced and low voltage (reduced shock current); residual current devices (sensitive, fast-acting trips); and double insulation (two layers of insulation).
- Outlined the importance of restricting work on electrical systems to competent persons only.
- Outlined the use of safe systems of work to control the high risks associated with work on or near electrical systems.
- Described an emergency procedure to be put in place if a person is injured in an electrical incident.
- Explained the importance of user checks, formal visual inspections and combined inspection and testing, which can be used to ensure the safety of all electrical installations, equipment and appliances, including portable appliances.

QUESTION

Outline control measures to reduce the risk of injury from electricity when using a portable electrical appliance on a construction site. (8)

IGC2, September 2010, Question 2

APPROACHING THE QUESTION

Think now about the steps you would take to answer the question:

1. The first step is to read the question carefully. This is an "outline" question – remember, that means you need to provide a brief description of the control measures, which might include some examples.

2. Next, consider the marks available. There are eight marks available here, which suggests that eight pieces of information are required.

3. Now highlight the key words. In this case, they might look like this:

   Outline control measures to reduce the risk of injury from electricity when using a portable electrical appliance on a construction site. (8)

4. Read the question again to make sure you understand it and have a clear understanding of the different ways in which the risk of electric shock can be reduced while using portable electrical equipment on a construction site. (Re-read your notes if you have to.)

5. The next stage is to develop a plan – you are now familiar with how to do this.

6. The answer plan will take the form of a bullet-pointed list that you need to develop into a full answer based on the key words that you have highlighted.

Now have a go at the question. Draw up an answer plan, and then use it as the basis to write out an answer as you would in the exam.

Key hint: if you aren't familiar with the construction environment, think about it as an outdoor workplace with vehicles and equipment in use.

When you have finished, compare your plan and full answer with those that follow.

SUGGESTED ANSWER

Plan

Controls for Portable Electrical Equipment on Construction Sites

- Reduced voltage.
- RCDs.
- Battery equipment.
- Armoured cables.
- Appropriate industrial equipment.
- Maintenance and testing.
- Visual checks by users.
- Avoid use in wet weather unless it is suitable for use.
- Training.

POSSIBLE ANSWER BY EXAM CANDIDATE

When portable electrical equipment is used on a construction site there are many controls that can be used to reduce the risk of injury from electric shock. Ideally, the use of mains voltage should be avoided and replaced by battery-powered tools. If this is not possible, the voltage could be reduced to 110 V – if this is generated by a centre-tapped transformer a person can't receive a shock of more than 55 V. The use of RCDs would also reduce the risk of injury by rapidly detecting fault currents and disconnecting from the supply. Where cables are used, these should be armoured to provide protection from the harsh environment, and located so as to avoid damage. Equipment should only be used in conditions that it was designed for - suitably robust, industrial equipment should be used rather than domestic equipment, and only suitable equipment should be used in wet conditions.

Users of electrical equipment should be trained to carry out simple visual inspections to detect simple faults before the equipment is used, and instructed when it should be taken out of use. Finally, maintenance should be carried out by competent persons to ensure that equipment, power supplies and cables are maintained in good working order.

REASONS FOR POOR MARKS ACHIEVED BY CANDIDATES IN EXAM

This question wasn't answered well in the exam. Many candidates simply lost marks for not providing the outlines required. Others didn't relate to the construction-site environment and discussed portable electrical equipment generally. Some candidates didn't consider portable equipment and talked about other construction-site equipment.

This is a good example of a question where marks were lost for not reading the question and not taking all of the clues offered. NEBOSH don't waste words – where a scenario is described, this is a useful clue!

FIRE SAFETY

ELEMENT 6

LEARNING OUTCOMES

On completion of this element, you should be able to demonstrate understanding of the content by applying what you have learnt to familiar and unfamiliar situations. In particular you should be able to:

1. Describe the principles of fire initiation, classification and spread.
2. Outline the principles of fire risk assessment.
3. Describe the basic principles of fire prevention and the prevention of fire spread in buildings.
4. Identify the appropriate fire alarm system and fire-fighting arrangements for a simple workplace.
5. Outline the factors which should be considered when implementing a successful evacuation of a workplace in the event of a fire.

Contents

Fire Initiation, Classification and Spread

KEY INFORMATION

- Three things must be present for a fire to start: fuel, oxygen and heat.
- The five classes of fire (determined by the types of fuel) are: Class A (organic solids), Class B (flammable liquids), Class C (flammable gases), Class D (metals) and Class F (high-temperature fats). (This is under the UK system; other national or regional systems may vary.)
- Fire can spread through a workplace by direct burning, convection, conduction and radiation.
- Fires have many different causes, but common ones are faulty or misused electric equipment, deliberate ignition, hot works, heating and cooking appliances, and smoking materials. The consequences of workplace fires include injuries and fatalities, damage to business, and harm to the environment.

PRINCIPLES OF FIRE

The basic principles of fire and combustion can be represented by the fire triangle:

The Fire Triangle

For fire to exist, three things must be present:

- **Fuel** – a combustible material or substance that is consumed during the combustion process. In a typical workplace, fuels can include paper and cardboard, wood and soft furnishings, structural materials, petrol and diesel fuels, butane, acetylene and other gases, solvents and other chemicals.
- **Oxygen** – consumed during combustion when it is chemically combined with the fuel. Oxygen is present in air at a concentration of 21%. During a fire oxygen can also come from other sources, including certain oxygen-rich chemicals (usually called **oxidising agents**), such as ammonium nitrate.
- **Sources of ignition (heat)** – a heat or ignition source is essential to start the combustion process. Once combustion has started it generates its own heat which is usually sufficient to keep the fire burning (in other words once the fire starts the heat source can be removed and the fire stays alight). Some examples will be described later in this element.

Once a fire has started it will produce heat, a flame (the zone where oxygen and flammable vapours are chemically combining in the combustion process) and smoke. The exact composition of the smoke will vary but typically smoke is made up of hot combustion gases such as carbon monoxide (CO) and carbon dioxide (CO_2) and small particles (soot).

The fire triangle is useful for two reasons:

- **Fire prevention** – if the three elements are kept apart fire cannot start.
- **Fire-fighting** – if one of the elements is removed the fire will go out.

CLASSIFICATION OF FIRES

Fires are classified into five categories according to fuel type. The classification is useful as the basis for identifying which type of fire extinguisher to use (see later). Note that the classifications shown here are those used in the UK; local classification systems may exist in other countries and regions, but the UK system provides a good example.

TOPIC FOCUS

Classification of fires:

- **Class A** – solid materials, usually organic, such as paper, wood, coal and textiles.
- **Class B** - flammable liquids, such as petrol, oil and solvents.
- **Class C** – gases, such as methane, propane and acetylene.
- **Class D** – metals, such as aluminium or magnesium.
- **Class F** – high-temperature fats and oils, such as cooking fat.

Note that there is no Class E fire. This classification was avoided because of potential confusion between Class E and electricity. Electricity is not a fuel (though it can be an ignition source).

GLOSSARY

FLAMMABLE

Easily ignited by a heat source at normal ambient temperatures. The words "combustible" and "inflammable" mean the same thing.

Note that the phrases "highly flammable liquid" and "extremely flammable liquid" have technical definitions that indicate these liquids can be ignited at low ambient temperatures.

Flammable liquid

PRINCIPLES OF HEAT TRANSMISSION AND FIRE SPREAD

Once a fire has started it can spread by four different methods: direct burning, convection, conduction, and radiation. In a real fire situation all four methods may apply.

TOPIC FOCUS

- **Direct Burning**
  The simplest method of fire spread, where a flame front moves along or through the burning material. For example, if the corner of a piece of paper catches fire, the flame front will spread across the paper.
- **Convection**
  The principle that hot air rises and cold air sinks. Hot gases generated by the fire rise straight up from the fire:
  - **Inside a building** these hot gases will hit the ceiling and then spread out to form a layer underneath the ceiling. When these hot gases touch any combustible material (such as a wooden curtain pole) they may heat that material up sufficiently so that it bursts into flame.
  - **Outdoors** these convection currents will contain burning embers that are carried on the currents until the air cools and the embers are dropped to the ground. This is a common way for forest fires to travel and jump over obstacles (such as roads).
- **Conduction**
  The principle that heat can be transmitted through solid materials. Some metals, in particular, conduct heat very efficiently (e.g. copper). Any pipes, wires, ducts or services running from room to room can act as conduits for heat and spread the fire.
- **Radiation**
  Heat energy can be radiated through air in the form of infrared heat waves, which travel in straight lines (just like light) and can pass through transparent surfaces (such as glass). Radiant heat generated by a fire shines onto nearby surfaces and is absorbed. If the material heats up sufficiently it can burst into flames.

COMMON CAUSES AND CONSEQUENCES OF FIRES IN WORKPLACES

Causes

Fires in workplaces start for many different reasons. Some of the most common causes of workplace fires are:

- **Electrical equipment** – faulty wiring, overloaded conductors, misused equipment and the incorrect use of electrical equipment in inappropriate environments (see Element 5).
- **Deliberate ignition** – many workplace fires are started deliberately. In some cases, the workplace has been targeted, e.g. by a disgruntled employee or an unhappy customer. In other cases, it has not, e.g. youths playing with matches on an industrial estate.
- **Hot work** – any work involving the use of naked flames (e.g. a propane torch or oxy-acetylene cutting equipment), or which creates a significant ignition source (e.g. arc-welding and grinding).
- **Smoking** – in particular, carelessly discarded smoking materials, such as cigarette butts and matches.
- **Cooking appliances**, e.g. fat pans left unattended.
- **Heating appliances**, e.g. electric fan heaters and space heaters, especially when left unattended.
- **Unsafe use and storage of flammable liquids and gases**, e.g. petrol, acetone and liquefied petroleum gas (LPG). Static sparks can be generated, which could ignite a flammable vapour.
- **Mechanical heat** – generated by friction between moving parts, such as a motor and its bearings, or cold work generating sparks.
- **Chemical reactions** - can also generate heat, e.g. oxidisers (rags soaked in oil and solvents are a fire hazard, because as the oil or solvents oxidise, heat is replaced and there is a risk of spontaneous combustion).

Unsafe storage of gas cylinders

Consequences

Fires cause enormous damage to buildings and building contents. Items that are not directly destroyed by the fire will often be severely affected by smoke damage. These losses will usually be covered by insurance, although the loss of business and premises are difficult to recover, leaving many people without jobs and a place of work.

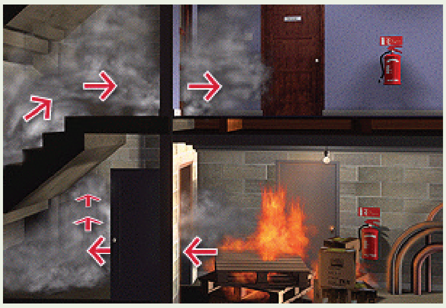
Perhaps of more concern are the consequences to people. Most of the people killed in workplace fires are not killed by the flames directly, but indirectly, by smoke inhalation. Serious burns may also result.

Fire and fire-fighting can also do significant damage to the environment. Forest fires (though not a significant risk in many parts of the world) do huge damage. Fire-fighting can cause pollution because of the large volumes of contaminated water that run off the fire site into watercourses.

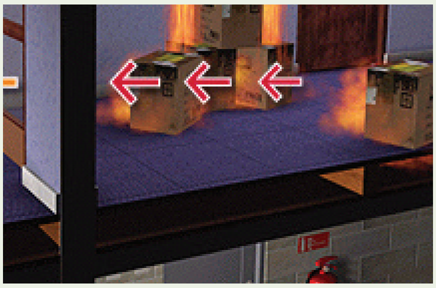
REVISION QUESTIONS

1. Explain briefly how each of the following might start a fire.
   (a) Friction.
   (b) Space heater.
2. What is likely to happen if you open a window to release the dense smoke in a room created by a fire?
3. Identify the fire classification of each of the following types of fire (using the UK system outlined in this element).
   (a) Butane gas cylinders burning in the storage area of a garden centre.
   (b) Fire in the paint shop of a car manufacturer.
   (c) Fire in an office.
4. Identify the process of heat transmission/fire spread shown in the following photographs.

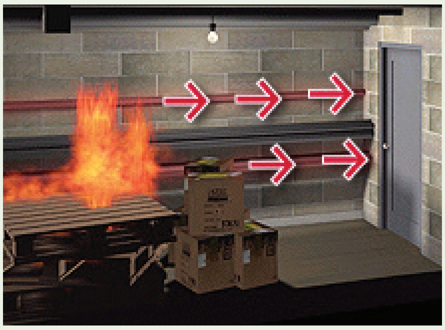
(a)



(b)



(c)



Source: Safe Practice "Fire Safety"

5. What additional method of heat transfer/fire spread is not illustrated by the photographs above?

(Suggested Answers are at the end.)

Fire Risk Assessment

KEY INFORMATION

Fire risk assessment is a five-step process to:

- Identify the fire hazards.
- Identify the people at risk from fire.
- Evaluate the risk from fire; remove or reduce the risks and protect from those risks.
- Record the findings; plan new controls; instruct and train those at risk.
- Review the assessment.

REASONS FOR CARRYING OUT A FIRE RISK ASSESSMENT

The three main reasons for assessing and managing fire risks are to:

- **Prevent harm to people** – all employers have a moral duty to take appropriate steps to ensure the health and safety of their employees and other people who may be affected.
- **Comply with the law** – employers have legal obligations regarding fire safety and can be penalised if they fail to meet those obligations.
- **Minimise the cost of fire in the workplace** – most businesses that suffer a major fire do not fully recover from its effects. If a factory or office burns down it may never be rebuilt, costing not only the business, but also the jobs of workers based there.

Fire risk assessment can also affect the overall level of risk (risk magnitude) of a company. A higher level of risk leads to a lower chance of competitive insurance premiums, and a greater chance of harming people, attracting negative publicity and losing orders – all of which affect a company's chances in the marketplace.

Carrying out a fire risk assessment allows a company to establish a suitable safety management system and fire safety policy so it can continue to appreciate and manage the risks from fire in the workplace, as well as assuring its business future at the same time.

FACTORS TO BE CONSIDERED IN FIRE RISK ASSESSMENT

Fire safety legislation and fire safety standards vary between countries, and from region to region. Fire risk assessment is a legal requirement in many countries (e.g. in the EU). However, some factors should be considered in any workplace; these can best be described by applying risk assessment methods to fire safety.

There are many different methodologies for carrying out a fire risk assessment. Here we are using one very similar to the five steps of general risk assessment but with special emphasis on fire safety:

- Identify the fire hazards:
  - Sources of fuel.
  - Sources of ignition.
  - Sources of oxygen.
- Identify the people who might be at risk:
  - People in the premises.
  - Give special consideration to vulnerable people.
- Evaluate, identify and implement the fire precautions that are required:
  - Fire prevention.
  - Prevention of the spread of smoke and flames.
  - Fire detection and alarm.
  - Fire-fighting equipment.
  - Means of escape.
  - Signs and notices.
  - Lighting.
- Record findings, plan and train:
  - Emergency plans.
  - Information and instruction.
  - Training.
- Review and revise the assessment as necessary.

Identify the Fire Hazards

At this stage the locations, types and amounts of the various potential fuels (combustibles) should be considered. All workplaces will contain simple combustibles such as paper, packaging materials and furniture. Some workplaces may contain large quantities of highly flammable, or extremely flammable materials, such as solvents, fuel or gases.

Potential ignition sources, and the frequency and duration of occurrence, are also important. Hot works, electrical equipment, portable fan heaters, etc. should all be taken into account, especially heat sources that are frequently used for long periods of time and that require special attention to ensure safety (e.g. hot work).

Sources of oxygen are significant factors to consider; oxygen cylinders and oxidising substances can both act as oxygen sources that can increase the risk of a fire starting and the severity of the fire.

Identify the People Who Might be at Risk

As with a general risk assessment, consider the general groups of people who might be affected by a fire in the workplace. These might be employees, contractors working on site, visitors, or members of the public. The number of people affected might be relatively small (e.g. 10 employees in a single workshop building) or very large (e.g. in a shopping centre).

Special consideration must be given to those who might be more at risk in a fire situation, such as:

- Lone workers (e.g. cleaners).
- Workers in isolated locations (e.g. maintenance staff in a boiler-house).
- Vulnerable groups, such as the very young (e.g. toddlers in a crèche), the elderly (e.g. residents in a care home) or the disabled (e.g. wheelchair users).

It might be acceptable in some instances to consider these people in groups, but in some cases it will be necessary to consider their particular needs on an individual basis. For example, a disabled worker in a multi-storey building may have impaired vision or impaired mobility; these two disabilities present very different problems and require different solutions.

Disabled people need special consideration

Evaluate, Identify and Implement the Required Fire Precautions

The risk of a fire occurring must be evaluated (as should existing precautions), as well as the risk to people. This can be done by thinking about:

- Potential fuels, ignition sources and oxygen sources.
- Methods by which fire might spread.
- How smoke and flames might travel in the workplace.
- The locations of the people in the premises.
- The structural fire resistance of the building (e.g. presence of timber structures).

A range of preventive and precautionary measures will be necessary for all workplaces. These will include the following issues, which are covered in more detail in the rest of this element:

- **Fire prevention** – ways of minimising the risks of a fire occurring.
- **Prevention of the spread of smoke and flames** – ways of minimising the risk to people should a fire occur and allowing them time to evacuate the premises safely.
- **Fire detection and alarm** – to ensure that a fire is detected as soon as possible once it has started and that every person in the premises is then alerted to the risk.
- **Fire-fighting equipment** – portable extinguishers and fixed installations.
- **Means of escape** – safe routes out of the premises to a place of total safety.
- **Signs and notices** – to indicate the escape routes and the emergency procedures.
- **Lighting** – to enable people to use the escape routes safely.

All these fire precautions have to be inspected, tested and maintained in effective working order. This requires that a regime of routine checks is carried out at various frequencies. Records of these checks should be kept.

Record, Plan, Instruct and Train

The **significant findings** of the fire risk assessment should be recorded according to the requirements of national or local regulations. The exact nature of the record will vary depending on the nature of the workplace. The record might include a line drawing of the workplace (i.e. a plan, as seen from above) showing the various fire precautions and the means of escape.

New controls should be planned and an **emergency plan** developed outlining the emergency procedures in the event of a fire. In a simple workplace this may be nothing more than a fire action notice. In a larger, more complex workplace, more detailed plans will need to be made. This may require consultation and co-operation with other occupiers or controllers of the premises. Again, there are likely to be local requirements with regard to how this information is recorded.

All relevant people (including employees, contractors and visitors to the premises) should be given appropriate instruction and training on **fire safety**. The nature of the instruction and training provided would vary, but should include fire prevention measures and emergency procedures.

Review

Regular review of the fire risk assessment will ensure that it stays relevant and suitable.

In particular, the risk assessment should be reviewed:

- After significant changes that might affect fire safety (e.g. a change to the fabric of a building, or the introduction of a new combustible material).
- After a fire emergency (to ensure that all precautions worked as intended).
- Periodically, to ensure that things have not been missed.

Temporary Workplaces

Fire safety must be provided for all workers at all times. If a workplace is temporary then a fire risk assessment should be carried out and fire precautions implemented. This is particularly the case on construction sites, where the nature of the work may mean rapid changes to the layout and nature of the workplace.

If an existing workplace is to be changed or modified in some way, and this will affect fire safety, then the fire risk assessment for those premises should be reviewed and revised as necessary. Depending on national legislation it may also be necessary to inform the fire regulation authority of the changes.

MORE...

In the UK, fire safety law and guidance documents for businesses are available from the Department for Communities and Local Government:

http://www.gov.uk/workplace-fire-safety-your-responsibilities/fire-safety-advice-documents

Similar publications may be available in other countries and regions.

REVISION QUESTION

6. Outline the five steps of a fire risk assessment.

(Suggested Answer is at the end.)

Fire Prevention and Prevention of Fire Spread

KEY INFORMATION

- Fire can be prevented by controlling potential fuel sources. Risk from fuel sources can be managed by elimination, substitution, minimising quantities, and by safe use and storage.
- Fire can also be prevented by controlling potential ignition sources, such as electrical equipment, hot works, discarded smoking materials, and cooking and heating appliances.
- Safe systems of work can be used to control work activities involving fire risk, e.g. permit-to-work systems can be used to manage the risk associated with hot works. This includes ensuring good standards of housekeeping.
- Flammable liquids must be used and stored with appropriate care to minimise the associated fire risk.
- If a fire does start within a building, structural measures will normally exist to contain the fire and smoke in one part of the building. This compartmentation must be maintained, and doorways should be properly protected with self-closing fire doors.
- Electrical equipment must be of a suitable category for use in an explosive atmosphere.

CONTROL MEASURES TO MINIMISE THE RISK OF FIRE IN A WORKPLACE

The best course of action to ensure fire safety is to prevent fires from starting. Fire prevention can be based on some simple ideas taken from the fire triangle:

- Control fuel sources.
- Control ignition sources.
- Control oxygen sources.

In particular, minimise these sources and keep them physically apart.

Control of Combustible and Flammable Materials

Combustible materials (such as paper, cardboard, wood and furnishings), flammable liquids (such as petrol and acetone) and flammable gases (such as butane, propane and methane) are all potential fuels and should be stored, handled, transported and used with appropriate care if the fire risk that they represent is to be controlled.

The best option is to **eliminate** the combustible and flammable materials and substances entirely from the workplace. This might be done, for example, by disposing of old stocks of materials and substances that are no longer needed.

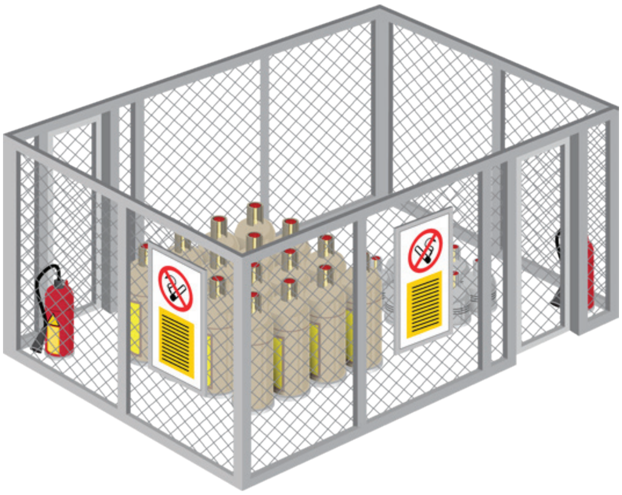
Alternatively, it may be possible to **substitute** one potential fuel source for another that presents less of a fire risk. For example, a petrol-powered generator might be changed to a diesel-powered one, eliminating the need to store and handle petrol. Since petrol is a highly-flammable liquid (i.e. easily ignited at lower ambient air temperatures) but diesel is not (i.e. not easy to ignite at ambient air temperatures) there is a considerable reduction in fire risk.

If combustible and flammable materials cannot be eliminated or substituted, then the quantities of these materials present in the workplace should be **minimised**. This requires good stock control, housekeeping and waste management. For example, cardboard is used extensively by many manufacturing companies as a packaging material. It will be stored in bulk in a warehouse. Minimising the stocks of cardboard reduces the fire risk in the warehouse.

For the combustible and flammable materials that remain arrangements must be made for **safe use and storage.**

For example, if liquefied petroleum gas (LPG) is present in a workplace the following arrangements should be made:

- Bottles (cylinders) should be stored outside.
- The storage area should be fenced with a secure, lockable gate.
- Warning signs should be displayed.
- Ignition sources should be eliminated from the area.
- Bottles should be kept upright and chained together.
- The storage area should be separate from other buildings.
- Empty and full bottles should be kept separate.
- Oxygen bottles should not be stored with LPG.
- Only those bottles actually required should be removed from the storage area and should be returned after use.



Cylinders stored outside

Control of Ignition Sources

Poor control of potential ignition sources is a common cause of workplace fires.

- **Electrical equipment** should be routinely inspected and tested to ensure that it is safe. This will prevent faults developing that might cause sparks or overheating. Both portable appliances and fixed installations should be checked.
- **Hot work** should be controlled with a permit-to-work system unless it is being carried out in a purpose-built area, such as a welding bay in a workshop.
- **Smoking** should be controlled in the workplace. It is illegal to smoke in indoor workplaces in some countries. Even when it is not illegal, smoking can be controlled by company policies that ban or restrict it. In all cases, attention must be given to the safe disposal of smoking materials.
- **Cooking and heating appliances** should be used carefully and their use closely supervised. In particular, they should not be left unattended.
- **Mechanical heat** (such as friction from machinery and bearings) can be controlled by routine maintenance.
- **Deliberate ignition** can be controlled by making good security arrangements for the workplace. A perimeter fence, security staff at entrances, CCTV, security lighting, etc. can help.

Systems of Work

Systems of work must be designed to minimise fire risk. The degree to which this is done and the exact procedures implemented should be decided through the risk assessment process.

An example of a safe system of work applied to fire safety is the use of a permit-to-work system to control hot work (where naked flames, or a significant ignition source will be created).

TOPIC FOCUS

Typical precautions for control of hot work:

- Combustible and flammable materials are removed from the work area.
- Items that cannot be removed are covered with fire-retardant blankets.
- The floor is swept clean.
- Any wooden floor is damped down.
- A suitable fire extinguisher is at hand.
- A "fire-watcher" is present in the area while the work is carried out.
- The work area is visited routinely after the work has finished to check the area for smouldering.

Good Housekeeping

Good housekeeping is fundamental to fire safety and is about keeping the workplace:

- Waste-free, by removing waste on a regular basis (e.g. emptying full litter bins) so that it does not build up and increase the fire risk as a potential fuel source.
- Tidy, so that combustible and flammable materials are returned to safe storage after use (e.g. solvents returned to the solvent store).
- Well-ordered, so that fuel and ignition sources are kept separate (e.g. ensuring fan heaters are not obstructed).

Pedestrian routes should also be kept clear (e.g. with no obstructions by the fire-escape door), so that they can be used in the event of a fire evacuation.

STORAGE OF FLAMMABLE LIQUIDS IN WORKROOMS AND OTHER LOCATIONS

Flammable liquids have a relatively low flash-point (between 21°C and 55°C) and can be quite easily ignited with a heat source (such as a match) at room temperature.

Highly flammable liquids have a lower flash-point (from around 0°C to 21°C) and are therefore easier to ignite.

Extremely flammable liquids have an even lower flash-point (well below 0°C) and are very easy to ignite at room temperature. Petrol (gasoline) is a common example of an extremely flammable liquid.

The lower the flash-point, the more dangerous the substance. It is therefore essential that flammable liquids are used and stored safely.

TOPIC FOCUS

Safe **use** of flammable liquids:

- Use the minimum volume of liquid required.
- Liquid should be in a properly labelled container.
- Ideally the container will be metal with a self-closing lid.
- Use a metal tray to catch spills and have absorbent material available.
- Use the liquid away from heat and ignition sources.
- Ensure that the workspace is well ventilated.
- Return containers to safe storage after use.

Safe **storage** of flammable liquids in **workrooms**:

- Store minimal volumes only.
- Store in a purpose-built flammables cabinet, which should:
  - Be fire-resistant (usually metal).
  - Have lockable doors and fire-resistant hinges and fastenings.
  - Be clearly signed.
  - Have a built-in catch tray to contain spillages.
  - Be located away from ignition sources.

Safe **storage** of flammable liquids in **other locations**:

- Store liquids in a purpose-built, single-storey flammables store, which should:
  - Be built of non-combustible materials.
  - Have a lightweight roof for explosion relief.
  - Ideally be built outdoors, away from other buildings, or with firewall protection.
  - Suitably fenced in a secure area.
  - Be well ventilated at high and low levels.
  - Have lockable access doors with sills to contain spillages.
  - Have clear and safe access for the fire service.
- All electrical systems should be intrinsically safe.
- All other ignition sources should be eliminated.
- Adequate fire-fighting equipment and suitable fire-safety signs should be provided.
- Regular checks for security, secure and safe storage, leaks of liquids, etc should be carried out.

STRUCTURAL MEASURES FOR PREVENTING THE SPREAD OF FIRE AND SMOKE

Example Scenario

If a fire starts on the ground floor of a large, open-plan multi-storey building that has open stairwells, convection will drive the hot smoke from the fire upwards. The smoke will fill the ground floor of the building and then rise up each of the open stairwells. Each stairwell will, in effect, become a chimney. The hot smoke will then fill the upper storeys of the building. The fire will not be contained and will spread through the building. The building will be destroyed, or suffer severe damage. Any people in the building, especially in the upper storeys, will become trapped and die as a result of fire and smoke inhalation because they will not have time to escape, and their escape route (the stairwells) will be full of smoke and flames.

Compartmentation

The above scenario is obviously undesirable. If fire prevention does not work and a fire does start in a building, it should be contained and prevented from spreading. This can be done by designing the building in such a way that it is divided up into separate **compartments**, each surrounded by fire-resistant materials that can resist the spread of smoke and flame.

This **compartmentation** is done at the initial design and build stage but may also have to be done if a building is changed or modified. This is normally a heavily legislated issue, which is subject to strict control and local standards.

If the multi-storey building in our scenario is compartmentalised, when the fire starts on the ground floor it will be contained in one part of the building. This will give time for the fire to be detected, the alarm raised and the building evacuated. Containment may result in the fire dying down or even going out as a result of oxygen starvation. If this does not happen, then the fire will eventually break through the containment, but this will take time.

Constructing walls, floors and ceilings from fire-resistant materials and ensuring that the building is broken up into appropriate compartments is only fully effective if any openings in the compartment walls are sealed. Since people have to move through buildings, doors must be fitted to openings. These doors must be built to withstand the spread of smoke and flames. Such doors are known as **fire doors**.

Typical characteristics of a fire door are:

- Rated to withstand fire for a minimum period of time (e.g. 30 minutes).
- Fitted with a self-closing device.
- Fitted with an intumescent strip.
- Fitted with a cold smoke seal.
- Vision panel of fire-resistant glass.
- Clearly labelled (e.g. Fire Door – Keep Shut).

GLOSSARY

INTUMESCENT STRIP

A strip built into the edge of a fire door that expands when it gets hot, sealing the gap between the door and the door frame.

COLD SMOKE SEAL

A plastic or foam strip that seals the gap between the door and frame at all times.

Note that these are typical characteristics of fire doors and the actual specification will vary according to need and local standards.

Heavier fire doors may be needed to:

- contain fire within compartments that contain greater fire risk (e.g. a plant room); or
- keep fire out of compartments that contain fire-sensitive contents (e.g. a computer room), in which case a higher rating will be required (one hour, two hours, etc.).

Most fire doors are fitted with a self-closing device that pulls the door shut once a person has walked through it. Some fire doors are fitted with electromagnetic openers that keep the fire door open at all times. If the fire alarm activates, or the electrical supply to the opener is interrupted, the door is released and closes. This type of door is common in corridors with heavy pedestrian traffic, where a normal fire door would be an obstruction.

Properties of Common Building Materials

Fire affects different building materials in different ways. The use of building materials, therefore, has to be tightly controlled to ensure that appropriate materials are used in a structure. For example, fire compartments must be robust enough to withstand the spread of fire for their design time, and structural elements in a building should not fail quickly when they are heated in a fire. There will be local regulation and standards to ensure fire safety.

- **Concrete** is usually very resistant to fire and does not collapse catastrophically. It may "spall" (throw off small chunks).
- **Steel** is severely affected by high temperatures. Expansion may occur, pushing structural elements apart. Steel may also twist and warp. These effects can lead to catastrophic building collapse.

  To overcome the problems associated with using steel as a structural material, it is usually encased in concrete or coated with a fire-retardant foam or paint (intumescent paint), which insulates it from excessive heat.
- **Brick** is usually very resistant to fire (bricks are made by exposure to very high temperatures in a kiln).
- **Timber** – thin timber, such as floor boards, will burn, but thick timber, such as structural beams, will not usually burn in a building fire (a layer on the outside of the timber will char and protect the inner core). Thick timber is unlikely to fail suddenly, but will do so slowly.

Other materials can also make a difference to fire resistance and the behaviour of a fire in a building:

- **Insulation** (such as wall insulation) can be combustible so fire-retardant versions must be used.
- **Wall coverings** (such as paint and wallpaper) can make a difference to the way fire spreads across surfaces, so they should also be closely controlled.

Protection of Openings and Voids

We have already noted that fire doors are used to ensure that door openings are protected in the event of fire. However, buildings, and the fire compartments that they are made up of, will inevitably have numerous voids and openings running through them, such as:

- Lift shafts.
- Service conduits.
- Air-handling ducts.
- Voids between floors.
- Roof voids, etc.

All of these need to be protected to ensure that smoke and flame cannot easily travel from one compartment to another. This protection can be done in many different ways, e.g. a self-closing shutter held open by a fusible link (a piece of soft metal that melts at a very low temperature, releasing the shutter).

It is important that any new openings made in fire break walls are reinstated or protected in some way, e.g. when cables are run through a hole in a wall the hole might be filled with fire-retardant foam.

ELECTRICAL EQUIPMENT FOR USE IN FLAMMABLE ATMOSPHERES

Electrical equipment sited in an atmosphere containing a mixture of a dangerous substance and air could well ignite that explosive atmosphere if it is not built to the correct specification. For example, in the UK a standard 230 V inspection lamp taken into a storage tank containing petrol vapour would act as the ignition source for that petrol vapour. Dusts and vapours can result in flammable or explosive atmospheres.

Legislation, such as the European ATEX directives, will govern the control of flammable atmospheres and the use of electrical equipment in those areas. There are two of these directives: the ATEX 95 Equipment Directive, which controls equipment available for supply for use in flammable areas; and the ATEX 137 Workplace Directive, which requires the workplace to be controlled to ensure safety of workers. ATEX takes its name from the French title of the directive: Appareils destinés à être utilisés en ATmosphères EXplosibles (Devices for Use in Explosive Atmospheres).

Broadly, the ATEX **Workplace Directive** requires the employer to classify hazardous locations into zones and then control the fire and explosion risks as appropriate, where:

- an explosive atmosphere might be created by the presence of a dangerous substance in a gas, vapour or mist form mixed with air; or
- an explosive atmosphere might be created by the presence of a combustible dust mixed with air.

The zones are classified on the following basis:

For **gases, vapours and mists** the zone classifications are:

- **Zone 0** – a place in which an explosive atmosphere is present continuously, or for long periods, or frequently.
- **Zone 1** – a place in which an explosive atmosphere is likely to occur in normal operation occasionally.
- **Zone 2** – a place in which an explosive atmosphere is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

For **dusts** the zone classifications are:

- **Zone 20** – a place in which an explosive atmosphere is present continuously, or for long periods, or frequently.
- **Zone 21** – a place in which an explosive atmosphere is likely to occur in normal operation occasionally.
- **Zone 22** – a place in which an explosive atmosphere is not likely to occur in normal operation but, if it does occur, will persist for a short period.

The employer would then be required to select the appropriate work equipment for use in the area. The ATEX **Equipment Directive** sets standards for the specification of electrical equipment that is intended for use in classified hazardous areas, as follows:

Electrical Equipment	Zone
Category 1	Zone 0 or Zone 20
Category 2	Zone 1 or Zone 21
Category 3	Zone 2 or Zone 22

Note that Category 1 equipment can be used in Zones 1 and 2 as well, and Category 2 equipment can be used in Zone 2. Such electrical equipment will be marked with an Ex sign in a hexagon, with a number indicating the category.

MORE...

Further information on controlling the risk of fire and prevention of fire spread is available from the UK Health and Safety Executive (HSE) and Department for Communities and Local Government:

http://www.hse.gov.uk/fireandexplosion/index.htm

http://www.gov.uk/workplace-fire-safety-your-responsibilities/fire-safety-advice-documents

REVISION QUESTIONS

7. How might you minimise the risk of fire in a woodworking area?
8. What precautions should be taken when using flammable liquids?
9. Outline the effects of fire on an unprotected steel beam.
10. Outline the typical characteristics of a fire door.

(Suggested Answers are at the end.)

Fire Alarm Systems and Fire-Fighting Arrangements

KEY INFORMATION

- When a fire starts in a building there must be an appropriate system to detect the fire early and raise the alarm with building occupants. A range of detection and alarm systems exists; larger workplaces have fully automatic fire alarm systems that rely on automated smoke or heat detectors linked into a central control system, which is, in turn, linked to alarm sounders/indicator lights.
- There must also be portable fire extinguishers available so that people can fight the fire, if necessary. Fire extinguishers contain different extinguishing media, such as water, carbon dioxide, foam and dry powder. Each type of extinguisher is designed for use on specific classes of fire in different circumstances and each has strengths and limitations.
- All portable fire extinguishers must be inspected and maintained routinely to ensure safe operation. Training should be provided for users so that they are able to use extinguishers safely and effectively.

FIRE DETECTION, FIRE WARNING AND FIRE-FIGHTING EQUIPMENT

Common Fire Detection and Alarm Systems

One of the most critical factors in determining whether people live or die in a fire in a workplace is how quickly the fire is detected and how quickly people are alerted. This is also a critical factor in determining how easily the fire will be controlled and extinguished.

Ideally, fires will be detected as soon as they start, and building occupants will be alerted to the presence of the fire immediately so that an appropriate response can be mounted. This response should usually be a full building evacuation and a call to the local fire service.

It is, therefore, essential that an appropriate fire detection and alarm system is used in a workplace. The exact type of system used will usually be subject to local regulation and standards, but some general principles can be applied:

- **The simplest system** – in a simple workplace, where all parts of the workplace can be seen by the occupants and there is no great fire risk, no detection or alarm system may be required. If there is a fire, people will see it and shout "fire". This may be acceptable as long as the workplace is not so large that some people would not hear that shout.
- **Simple, with more noise** – if the workplace is simple and low-risk, but large enough that building occupants might not hear a shouted alarm, then a hand-operated alarm might be used (such as a hand bell, whistle, or air horn).
- **Manually-operated fire alarm** – this system can be manually activated at call points. These call points are usually buttons behind a clear plastic disc that, when hit, breaks, activating the system. The system will have a central control box and sounders (and/or lights) at positions throughout the workplace that give the alarm.
- **Interlinked smoke alarms** – if there are rooms (such as plant rooms or stores) that are not normally occupied (so a fire might start there and no one would notice), then a simple automatic detection and alarm system might be fitted, made up of interlinked smoke alarms. This consists of individual ceiling-mounted units that both detect smoke from the fire and give the alarm sound, and which are linked together so that when one sounder activates all of the sounders emit the alarm.

A ceiling-mounted smoke alarm

- **Automatic fire alarm** – a system made up of automatic detectors and manual call points linked into a central control box, which is linked, in turn, to sounders (and/or lights). If a person sees the fire they can activate a manual call point and raise the alarm. If there is no person present then the automatic detectors will activate the system and raise the alarm. This type of system is commonly used to protect medium to high-risk workplaces, multi-storey buildings and workplaces where sleeping accommodation is provided (such as care homes).

  An automatic fire-alarm system can be quite simple or very complicated, depending on the workplace in which it is installed. In some workplaces the building is subdivided into zones and the fire-alarm system can give different warning sounds depending on which zone the fire was detected in. In this way, phased evacuations (see later) can be achieved.

The type of automatic fire detector that is used with a fire-alarm system also varies depending on the situation.

- **Smoke detectors** are very common, and:
  - Detect small smoke particles, are usually very sensitive and give early warning.
  - Are of two main types: ionising and optical.
  - Can give rise to false alarms if used in a humid, wet, dusty or smoke-filled atmosphere.
- **Heat detectors** are more suitable for certain applications, and:
  - Detect the excess heat generated by a fire, are usually less sensitive and give later warning.
  - Come in two main types: 'rate of rise' and 'fixed temperature'.
  - May not detect smouldering fires that are giving off smoke but not much heat.

Portable Fire-Fighting Equipment

If a fire starts in a workplace it may be possible to extinguish that fire quickly and effectively using a portable fire extinguisher. This might be done with minimal risk to the user, preventing the fire from escalating, potentially saving life and property. If there is no portable fire extinguisher present then there may be no choice but to leave the fire to burn out of control.

A portable fire extinguisher in use

In addition to portable extinguishers, other fire-fighting equipment can be found in workplaces:

- **Fire blankets** – used to physically smother small fires. Very useful for cooking areas where fat fires might occur, and also for smothering burning clothing.
- **Hose reels** – sited in buildings to allow fire teams to fight fires.
- **Sprinkler systems** – sited in buildings and warehouses to automatically damp down a fire.

Siting, Maintenance and Training

Fire extinguishers and other fire-fighting equipment should be **positioned** on fire exit routes near exit doors and close to the specific hazard that they are provided to protect against (e.g. a fire blanket close to a gas hob in a kitchen). They should be clearly visible and signed.

Fire extinguishers should be **inspected and maintained** routinely to ensure that they are always available in safe working order:

Frequent routine inspections – to ensure that extinguishers are present at their designated positions and that they appear to be in good order (with their firing pin still tagged in place). This might be done as part of a routine housekeeping inspection, or as a specific fire safety check.

Planned preventative maintenance – to ensure that they remain in safe working order. This is normally carried out on an annual basis by a certificated engineer and may involve inspection, testing and dismantling (depending on the type of extinguisher).

Records should be kept of visual inspection and maintenance checks carried out. This will usually be the subject of local regulation and codes of practice.

Workers who might have to use portable fire extinguishers must be **trained** in their safe use. This training should include theoretical training (classroom-based) and also some practical training (this will normally involve workers using real fire extinguishers to put out real fires, set up under controlled circumstances, either at the workplace or at a training centre). It should include:

- General understanding of how extinguishers operate.
- Importance of using the correct extinguisher for different classes of fire.
- Practice in the use of different extinguishers.
- When to tackle a fire, and when to leave it alone.
- When to leave a fire that has not been extinguished.

Records should be kept of training provided. Again, this may be the subject of local regulations and codes of practice.

Extinguishing Media

Fire extinguishers are usually coloured red. In some countries a colour-coding system is used for extinguishers to enable quick recognition of the different types, but this colour-coding is not universal.

TOPIC FOCUS

The following types of portable fire extinguisher are commonly found in workplaces (note that the classes of fires used here refer to the UK classification system outlined earlier):

- **Water** – suitable for Class A fires. Works by cooling the fire. Standard water extinguishers are not suitable for use on Classes B, D or F fires or live electrical equipment (risk of shock). Certain specialised water extinguishers are available for use on Class B and F fires.
- **Carbon dioxide** – suitable for Class B fires, especially fires involving live electrical equipment. Works by smothering the fire. Not suitable for use on Class D fires. Must be used with care because the body of the extinguisher gets very cold during use and can cause a freeze-burn injury.
- **Foam** – suitable for Class A and B fires. Works by smothering the fire, or by preventing combustible vapours from mixing with air.
- **Dry powder** – suitable for all classes and use on live electrical equipment. Works by smothering the fire. Can be very messy.

	WATER	FOAM	CARBON DIOXIDE	POWDER	WET CHEMICAL
A	✓	✓		✓	
B	✗	✓	✓	✓	
C				✓	
D				✓	
F					✓
⚡	✗	✗	✓	✓	

Classes of fire and extinguishing media (fire classification and extinguisher colour-coding systems are those used in the UK)

Access for Fire and Rescue Services and Vehicles

Fire-Fighting Vehicle Access

Fire engines need to be able to get close to the perimeter of a building so they can position and deploy high-rise equipment such as turntable ladders, hydraulic platforms and pump appliances with fire-hoses. The fire regulations in some countries and regions (especially the EU) may place a duty on occupiers of premises to maintain such access.

The requirements for vehicle access differ depending on the presence of **fire mains**, the **size of the building** and the **type of fire appliance** to be used:

- For **small buildings** without a fire main, access for a pump appliance should be provided to 15% of the perimeter, or to within 45 metres of every point on the building surrounds.
- For **large, high-rise buildings**, the entire perimeter will need to be accessible to fire-fighting appliances.

GLOSSARY

FIRE MAIN
A water supply pipe installed specifically for fire-fighting purposes.

Access to Buildings for Fire-Fighting Personnel

For high-rise buildings, a protected fireman's shaft may be needed, which combines such facilities as a fire-fighting lift, fire-fighting stairs and fire-fighting lobbies. The requirements will depend on the size and design of the building and whether it has automatic sprinkler systems.

Fire-fighters require information relating to the contents of the building and any hazardous materials, or processes and facilities that might create a risk to them while they carry out their duties. The emergency plan that the company has in place should include arrangements for nominated and competent persons to liaise with the fire service on their arrival.

REVISION QUESTIONS

11. What are the limitations of manual alarm systems and how may they be overcome?
12. Identify the two main types of automatic fire detector.
13. Outline the main points to be covered in training in the use of fire extinguishers.
14. Identify the three ways of extinguishing a fire.
15. Identify the classes of fire (using the UK classification system outlined in this element) for which each of the following extinguishing media is suitable.

    (a) Water.

    (b) Carbon dioxide gas.

    (c) Dry powder.

    (d) Foam.

(Suggested Answers are at the end.)

Evacuation of a Workplace

KEY INFORMATION

- The means of escape is the route that a person will take from wherever they happen to be in a building to a safe place outdoors.
- There are many factors that influence the means of escape, such as: travel distances; number of available escape routes; escape route width; design of any doors in the escape route; and provision of suitable assembly points.
- In particular, the means of escape must be properly signed and provided with emergency lighting, where necessary.
- Every workplace must have procedures to ensure the safe evacuation of people from buildings in the event of fire.
- These procedures will require nominated staff to carry out certain duties, such as to act as fire marshals. These staff should be trained in their specific role.
- Information on fire evacuation procedures should be provided to others, as appropriate.
- Fire drills allow staff to practise their emergency response and allow management to monitor the effectiveness of emergency arrangements.
- Special procedures may be required to ensure the safe evacuation of the infirm or disabled.
- Means of escape should be shown on the plans of a building.

MEANS OF ESCAPE

When a fire emergency occurs and people have to evacuate a workplace there must be one or more escape routes available for them to use. This escape route is the "means of escape". Local regulations, codes of practice and standards vary in determining exactly what might be required in each specific circumstance, but the following general principles can be applied:

- There should be a means of escape available to every person in a workplace, whether they are in an office, workroom, plant room, basement, on the roof, or on a scaffold on a construction site.
- The means of escape should allow an able-bodied person to travel the entire route by their own unaided effort. They should not have to use machinery (such as a passenger lift) except in special cases (when the machinery must be rated for escape purposes).
- The means of escape must take a person from wherever they are in the workplace to a place of safety outside the building where they are able to move away unrestricted.
- Two or more separate escape routes may have to be provided so that if one route is blocked there is another available. This is common in high occupancy multi-storey buildings.
- The travel distance that a person has to cover from their location in the building to the final exit out of the building should be as short as possible (and must normally meet specific maximum distance criteria).
- The width of corridors, passageways and doors should be sufficient to allow the free and fast movement of the numbers of people that might be anticipated (and must normally meet specific minimum width criteria).
- The escape route should be clearly signed and appropriately lit.
- Emergency lighting should be provided where necessary (in case the mains power supply fails).
- The route that a person has to take should be unimpeded by obstructions such as stored material or inappropriate doors.

Many factors affect the exact specification of the means of escape. Two important factors are the number of people that will be occupying any given room or area, and the general level of fire risk of the workplace. So, for example, the means of escape for a low-risk workplace with a small number of employees present (e.g. 10) might consist of one exit involving a long travel distance. However, this would be unacceptable for a high-risk workplace with a large number of employees (e.g. 200), where several alternative exits with short travel distances would be required.

Travel Distances

One important characteristic of the means of escape is the travel distance that a person has to take from wherever they are in a room or area to the nearest available:

- Final exit (which takes the person outside the building to a place of total safety).
- Storey exit (which takes the person into a protected stairway).
- Separate fire compartment (which contains a final exit).

This travel distance has to be assessed during the fire risk assessment when determining the means of escape and is subject to guidance. Generally, the higher the fire risk of the workplace, the shorter the travel distance has to be.

The number of exits is another important characteristic of the means of escape. In some instances it may be acceptable to provide just one exit route from a room or area. However, if the fire risk is high, the number of occupants is high, or travel distances are long, two or more exits should be provided. The underlying principle of having two exits is that a person can turn in two completely different directions and then has two completely separate routes through and out of the building.

Stairs and Passageways

Stairs and passageways used as means of escape usually have to be protected against fire ingress to a higher degree than other parts of a building to ensure that they will be free of smoke and flame, so that they can be used as escape routes. The walls, floor and ceiling will, therefore, be fire-resistant and any doors will be fire doors. It is important that these stairs and passageways are kept free of any equipment or materials that might start, or become involved in, a fire.

Doors

Doors in the means of escape must be suitable, and:

- Easily operated by a person in a hurry.
- Wide enough to allow unimpeded passage.
- Open in the direction of travel (though this is not usually a strict requirement where occupancy numbers are low).
- Able to be opened at all times when they might be needed (not locked in such a way that a person in the building cannot open them).

Emergency (Escape) Lighting

Escape routes should be adequately lit. Normal workplace lighting will normally achieve this, but there should be arrangements to cover non-routine situations (such as night-time working) and power failures. Emergency escape lighting may be necessary where power failure will result in a blackout. In very simple workplaces this may be a rechargeable torch but in many workplaces emergency escape lighting units are required. Emergency escape lighting should:

- Illuminate the escape route.
- Illuminate fire signs and equipment.
- Be maintained in safe working order.
- Be tested routinely.

Exit and Directional Signs

The escape route should be easy to follow. Signs should be provided so that people can see the direction of their available escape routes quickly and easily, leading all the way to a final exit, also signed. These signs should meet relevant regulations, standards, etc. and be carefully selected and fixed so that they are very easy to interpret. Some signs, especially in critical positions, can also incorporate escape lighting, while others may be photo-luminescent (signs that "glow in the dark").

A fire escape sign

Evacuation of a Workplace

Assembly Points

An assembly point is a place where workers congregate once they have evacuated a building. This allows for a roll call to be taken and any missing persons to be identified.

Assembly points should be:

- A safe distance from the building (it may be on fire).
- At a safe location (not in a high hazard area).
- At a location where further escape is possible if needed.
- Out of the way of fire-fighters.
- Clearly signed.

In some cases, a temporary assembly point or "refuge" may be provided inside a building. This is a protected location (normally on or adjacent to a main means of escape) where people can wait for a short time. This might be used as a location where a person with impaired mobility temporarily waits for assistance to evacuate the building.

TOPIC FOCUS

Fire Plans

The following factors should be considered when developing a fire plan:

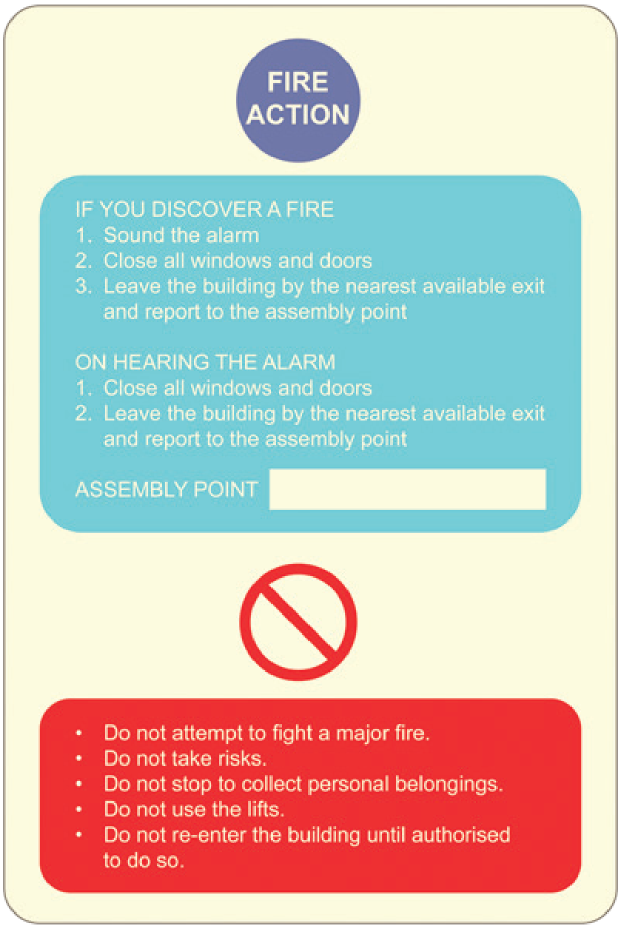
- Details of who is likely to be in the building:
  - Workers.
  - Visitors.
  - Contractors.
  - Vulnerable persons.
- Action to be taken by the person who finds the fire:
  - How will the alarm be raised?
  - How will the emergency services be contacted (will this be an automatic system, or will someone be required to phone the fire service)?
- Escape routes:
  - Number and location.
  - Travel distances.
  - Provision of fire exit route signs.
  - Emergency lighting of escape corridors and stairwells.
- Fire-fighting equipment:
  - Provision of portable equipment (types and location).
- Action to be taken after evacuation:
  - Roll call.
  - Fire marshals to check building is evacuated.
- Training:
  - In use of equipment.
  - Fire drills.
  - Co-operation with other employers on site.

Emergency Evacuation Procedures

Every workplace should have formal documented procedures in place to deal with fire emergencies, including:

- Evacuation procedures.
- Nominating responsible staff to fulfil certain roles.
- Training staff and providing information to visitors and members of the public.
- Conducting drills to test procedures.

Emergency procedures must be developed so that staff know what to do in the event of foreseeable fire emergencies. Appropriate procedures should tell people the action to take if they discover a fire and what to do if the alarm sounds. These procedures are usually quite simple:



Notice displaying typical fire procedures

The emphasis in any procedures must be on personal safety and the key message must be to **sound the alarm, get out and stay out!**

More complicated procedures may have to be developed for certain situations. For example, in a hospital, rather than use the basic approach given in the sample procedure above, it might be more appropriate to carry out a **phased evacuation**. Here, only those in the immediate vicinity of the fire are evacuated at first, followed by a gradual evacuation falling back from the seat of the fire. In this way, the large numbers of people and the practical issues associated with moving the infirm might be managed more easily.

Training and Information

All employees in a workplace should be provided with basic information about fire safety in general and the fire procedures in particular. This should be done at induction and might be repeated periodically, or as the need arises.

Information on fire procedures should also be provided to contractors and visitors, perhaps through induction training programmes, or by providing written information.

Informing members of the public about fire procedures can be more of a problem since, in many workplaces, they can walk in off the street and there is no opportunity for providing written information (e.g. at a shopping centre). In these circumstances, a public address (PA) system may be the best way of keeping the public informed of an emergency situation and the action that they should take.

Appropriate training should be provided to staff who:

- Might have to use portable fire extinguishers, or other fire-fighting equipment.
- Have a fire marshalling role (see below).
- Will be helping infirm or disabled people during an evacuation.
- Are members of the fire team.

Records of all training should be kept.

Employers should take into account the health and safety capabilities of employees when entrusting them with fire safety tasks. This will apply at all levels of employee training, including competent persons, fire marshals, etc.

FIRE MARSHALS

Whatever the fire evacuation procedures are, there will always be the need for some members of staff to take on particular roles in the emergency situation, perhaps as nominated "fire marshals" (sometimes called "fire wardens") to take roll calls of workers at assembly points and report back to a responsible manager.

Fire marshals might be required to:

- Check all areas in the building to ensure that everyone knows that an evacuation is in progress and to help where necessary. This is common practice in buildings where members of the public may be present (e.g. shopping centres).
- Give special assistance to the disabled and infirm. This may require the use of special evacuation equipment such as an "evac-chair".
- Investigate the site of the fire (as indicated by the fire alarm system controls).

Some workplaces operate a **fire team** whose role involves investigation of fire alarms and fire-fighting. High-risk installations may even have their own in-house fire-fighters with all the vehicles, equipment and resources that might be available to the emergency services (e.g. at an airport).

FIRE DRILLS

Fire evacuation arrangements need to be tested by carrying out fire drills. Some of these may be in response to false alarms, but others should be planned.

Fire drills:

- Allow workers to practise emergency procedures.
- Enable the effectiveness of procedures to be tested to ensure that fast, effective evacuation of the building takes place and that all workers behave in an appropriate manner.

Records of fire drills, learning points and follow-up actions should be kept.

Roll Call

Once workers and contractors have evacuated a building and collected at their assembly points, it is usual to take a roll call to ensure that all persons are accounted for and no one is missing. This means that arrangements must be made for taking an effective roll call; accurate lists of names of those on site must be produced and responsible individuals given the task of taking the roll-call.

In some cases, a roll call will be impractical, so an alternative method of ensuring that people have evacuated from the workplace will be required (e.g. building checks by fire marshals).

Provision for the Infirm and Disabled

Staff with hearing or other disabilities must be accommodated within an evacuation plan. Plans must be in place to assist people in wheelchairs who cannot use stairs if a lift is inactivated (in most cases, lifts and escalators are not appropriate as escape routes). Provision must also be made for the needs of other groups with limited mobility, such as children and elderly people. Temporary illness and infirmity must also be taken into account, e.g. a worker with a broken leg must be accommodated in the evacuation plan.

When putting these arrangements in place, the nature and degree of disability or infirmity should be taken into account, ideally in consultation with the individual concerned. Various solutions might then be considered: For example:

- A worker with some hearing impairment might be capable of hearing the audible fire alarm in their work area, so no special arrangements are required.
- A profoundly deaf worker might not be able to hear the audible alarm, in which case a visible alarm (flashing light) might be used in conjunction with the audible alarm; or a buddy system might be adopted where a colleague alerts the worker to the fire alarm; or a technical solution might be sought involving a vibrating pager.
- A wheelchair user above ground level in a multi-storey building might be provided with a refuge adjacent to the stairwell (a protected area where they can wait for a short period of time). They might then be helped down the stairs by nominated responsible individuals, perhaps with the aid of an "evac-chair". Note that they should not be left alone in the refuge and that their safe evacuation is usually considered the responsibility of their employer, not the fire and rescue service.

BUILDING PLANS

The means of escape should be shown on the plans of a building. These plans usually constitute one of the records contained in the fire risk assessment. In some situations building plans should be displayed in the building (e.g. in a multi-storey building, a plan of each floor may be displayed on that floor) so that those within it can clearly see what their escape routes should be. Examples of building plans are often found on the back of hotel-room doors.

REVISION QUESTIONS

16. What is the purpose of signs used on escape routes?
17. Outline the main requirements for an escape route.
18. What is an assembly point and how might it differ from a refuge?
19. Suggest actions for which fire marshals might be responsible when an evacuation takes place.
20. What should take place at an assembly point following an evacuation?

(Suggested Answers are at the end.)

SUMMARY

This element has dealt with some of the hazards and controls relevant to fire in the workplace. In particular, this element has:

- Outlined some of the basic principles of fire such as: the fire triangle; classification of fires; the methods by which fire can spread; and some of the common causes and consequences of workplace fires.
- Described the reasons for carrying out a fire risk assessment, and shown fire risk assessment as a five-step process of identifying fire hazards; identifying the people who might be at risk; evaluating, identifying and implementing fire precautions required; recording the findings, planning and training; and reviewing and revising the assessment as necessary.
- Outlined the factors to be considered during fire risk assessment, including consideration of temporary workplaces and changes to workplaces.
- Explained how fire and the spread of fire can be prevented by controlling potential fuel sources (e.g. safe use and storage of flammable liquids) and potential ignition sources (e.g. hot work).
- Outlined the structural measures that exist to contain fire and smoke in the event of a fire starting, and the use of self-closing fire doors to protect door openings.
- Described the general principles of fire detection and alarm systems.
- Discussed the main types of fire extinguisher commonly used, such as water, foam, dry powder and carbon dioxide, and the strengths and limitations of each type.
- Outlined the need for electrical equipment used in flammable atmospheres to be suitable for such environments (with reference to the European ATEX directives).
- Outlined the principal characteristics of a means of escape, such as: travel distances; number of available escape routes; escape route width; design of any doors in the escape route; assembly points; signage; and emergency lighting.
- Described basic requirements for evacuation procedures, fire marshals, training and information, fire drills and special procedures for the infirm or disabled, and the inclusion of escape routes in building plans.

QUESTION

Identify EIGHT common causes of fires in the workplace. **(8)**

IGC2, September 2010, Question 3

APPROACHING THE QUESTION

Think about the steps you would take to answer the question:

1. The first step is to read the question carefully. This time you have been asked to "identify" eight common causes of fire. You will remember that when asked to "identify" NEBOSH want you to "select and name".

2. Next, consider the marks available. Here, you are asked for eight causes of fire - each will be worth one mark.

3. Now highlight the key words. In this case, almost all of the words are critical:

   Identify EIGHT common causes of fires in the workplace. (8)

4. Read the question again to make sure you understand the causes of fire in the workplace. (Re-read your notes if you have to.)

5. The next stage is to develop a plan – you are now familiar with how to do this.

6. The answer plan will take the form of a bullet-pointed list that you need to develop into a full answer based on the key words that you have highlighted.

Now have a go at the question. Draw up an answer plan, and then use it as the basis to write out an answer as you would in the exam.

When you have finished, compare your plan and full answer with those that follow.

SUGGESTED ANSWER

Plan

Common Causes of Workplace Fires

- Discarded smoking materials.
- Electrical faults/overheating.
- Friction, e.g. grinding gears.
- Blocked vents on electrical equipment.
- Static discharge.
- Welding and grinding.
- Hot surfaces, e.g. cooker hotplates.
- Arson.
- Incorrect use of equipment.
- Chemical reactions.

Now have a go at the question yourself.

POSSIBLE ANSWER BY EXAM CANDIDATE

Eight common causes of fire in the workplace are:

- *Arson – many fires are started deliberately.*
- *Carelessly discarded smoking materials, possibly owing to smoking in unauthorised areas.*
- *Electrical faults resulting in overheating or overloading.*
- *Friction, e.g. grinding gears due to poor maintenance.*
- *Chemical reactions resulting in heat being generated.*
- *Static discharge igniting flammable vapours when handling solvents.*
- *Sparks while welding.*
- *Contact with intentionally hot surfaces, such as cooker hotplates.*

REASONS FOR POOR MARKS ACHIEVED BY CANDIDATES IN EXAM

This question was generally well answered but only one mark was available for electrical equipment, so candidates giving several electrical causes of fire lost marks. It was also important to identify the causes of fire and not just the ignition source.

CHEMICAL AND BIOLOGICAL HEALTH HAZARDS AND RISK CONTROL

ELEMENT 7

LEARNING OUTCOMES

On completion of this element, you should be able to demonstrate understanding of the content by applying what you have learnt to familiar and unfamiliar situations. In particular, you should be able to:

1. Outline the forms of, the classification of, and the health risks from exposure to hazardous substances.
2. Explain the factors to be considered when undertaking an assessment of the health risks from substances commonly encountered in the workplace.
3. Describe the use and limitations of occupational exposure limits, including the purpose of long-term and short-term exposure limits.
4. Outline control measures that should be used to reduce the risk of ill-health from exposure to hazardous substances.
5. Outline the hazards, risks and controls associated with specific agents.
6. Outline the basic requirements related to the safe handling and storage of waste.

Contents

Hazardous Substances: Forms, Classification and Health Risks

KEY INFORMATION

- Chemicals are encountered in different physical forms such as dusts, fumes, gases, mists, vapours and liquids. The form significantly affects how these substances might enter the body.
- Biological agents such as fungi, bacteria and viruses can be hazardous to health.
- Chemicals are classified according to their hazardous properties as: toxic, harmful, corrosive, irritant or carcinogenic.
- Hazardous substances often have an acute (or short-term) effect, or they may have a chronic (or long-term) effect.

Exposure to chemical and biological health hazards can cause an immediate health risk (e.g. carbon monoxide (CO) gas can cause asphyxiation) or even physical injury (e.g. corrosive skin burn from sulphuric acid). Less obviously, exposure can also have long-term health effects, which may build gradually over time (e.g. lead poisoning) and, in some instances, will not be apparent until years after the exposure that caused them (e.g. lung cancer caused by asbestos). We will now look at the forms and classification of chemicals and biological agents that cause these short-term and long-term health effects.

FORMS OF CHEMICAL AGENTS

The physical form of a chemical makes a big difference to how easy it is for that chemical to enter the body. For example, a bar of stainless steel contains hazardous metals such as chromium and nickel, but they cannot enter the body when the bar is in its solid massive state. But if the bar is welded, then a welding fume is generated and these metals become airborne; now they can be inhaled into the lungs.

Large dust cloud created by disc cutting concrete

The physical forms of chemicals are:

- **Solid** – a solid block of material (e.g. a lead ingot).
- **Dust** – very small solid particles normally created by grinding, polishing, milling, blasting, etc. and capable of becoming airborne (e.g. flour dust, rock dust).
- **Fume** – very small metallic particles that have condensed from the gaseous state during work with molten metal (e.g. welding) to create an airborne cloud.
- **Gas** – a basic state of matter; expands to fill the space available (e.g. carbon dioxide (CO_2)).
- **Mist** – very small liquid droplets suspended in air, normally created by spraying (e.g. paint spraying).
- **Vapour** – the gaseous form of a substance that exists as a solid or liquid at normal temperature and pressure (e.g. vapour given off by acetone solvent).
- **Liquid** – a basic state of matter; free-flowing fluid (e.g. water at 20°C).

FORMS OF BIOLOGICAL AGENTS

Biological agents are micro-organisms: They can be categorised as follows:

- **Fungi** – moulds, yeast and mushrooms. Most are harmless to humans but some can cause disease, such as fungal infections (e.g. athlete's foot) and farmer's lung (an allergic irritation caused by inhaling mould spores).
- **Bacteria** – single-celled organisms that are found in vast numbers in and on the human body. Some are harmless, some are beneficial (certain gut bacteria) and some cause disease (e.g. legionnaires' disease, leptospirosis).
- **Viruses** – very small infectious organisms that reproduce by hijacking living cells to manufacture more viruses. Many viruses cause disease (e.g. hepatitis).
- **Prions** - abnormal, transmissible agents able to induce abnormal folding of normal cellular prion proteins in the brain, leading to brain damage (e.g. Creutzfeldt-Jakob Disease (CJD or "mad cow" disease and variant CJD)).

CLASSIFICATION OF CHEMICALS HAZARDOUS TO HEALTH

Chemicals can be broadly classified according to three types of danger:

- Physico-chemical effects – such as highly flammable, explosive or oxidising.
- Health effects – such as toxic or carcinogenic.
- Environmental effects – such as harmful to aquatic life.

In this element we are concerned with the **health effects**. These can be further subdivided to give a variety of classifications that indicate how the chemical actually affects health.

TOPIC FOCUS

Classification of chemicals hazardous to health:

- **Toxic** – small doses cause death or serious ill-health when inhaled, swallowed or absorbed via the skin (e.g. potassium cyanide (KCN)).
- **Harmful** – cause death or serious ill-health when inhaled, swallowed or absorbed via the skin in large doses.
- **Corrosive** – destroy living tissue on contact (e.g. concentrated sodium hydroxide (NaOH)).
- **Irritant** – cause inflammation of the skin or mucus membranes (e.g. eyes and lungs) through immediate, prolonged or repeated contact (e.g. ozone (O_3)).
- **Carcinogenic** – may cause cancer (abnormal growth of cells in the body) when inhaled, swallowed or absorbed via the skin (e.g. asbestos).

(**Note** that there are two categories of substance that are infrequently found in workplaces but can be of great concern when they are present:

- **Mutagens** – may cause genetic mutations that can be inherited.
- **Toxic to reproduction** – may cause sterility, or affect an unborn child.)

Some chemicals are **sensitising agents**. This means that they are capable of producing an allergic reaction that will gradually worsen on repeat exposures.

There are two groups of sensitising chemicals:

- **Skin sensitisers** – can cause allergic dermatitis on contact with the skin (e.g. epoxy resin).
- **Respiratory sensitisers** – can cause asthma on inhalation into the lungs (e.g. flour dust and isocyanates).

GLOSSARY

DERMATITIS

A non-infectious skin condition where the skin becomes dry, flaky, cracked and painful. Usually reversible with treatment.

ASTHMA

A condition where the airways of a person's lungs become irritated in response to a trigger, constricting in size and producing excess mucus, making breathing difficult.

Typical symptoms of dermatitis: dry, flaky, inflamed skin

There are two main types of dermatitis associated with exposure to hazardous substances:

- **Primary contact dermatitis** - following immediate, repeated or prolonged contact with a primary skin irritant. This dermatitis is restricted to the skin that was in contact with the irritant substance only.
- **Allergic or secondary contact dermatitis** - following immediate, repeated or prolonged contact with a skin sensitising agent. This form of dermatitis often appears on different parts of the body other than the point of contact with the substance and can flare up in response to very small exposures once the person has become sensitised.

ACUTE AND CHRONIC HEALTH EFFECTS

Two different types of effect can occur when a person is exposed to a hazardous substance:

- **Acute effects** – as a result of exposure to high levels of the substance, sometimes over very short periods of time, and usually quite quickly after exposure begins (seconds, minutes, or hours), e.g. exposure to high concentrations of chlorine gas causes immediate irritation to the respiratory system.
- **Chronic effects** – as a result of exposure to lower levels of the substance, over long periods of time, and usually weeks, months, or years after exposure began, e.g. asbestosis occurs 10-20 years after multiple exposures to asbestos.

Note that many hazardous substances can have both acute **and** chronic effects. For example, exposure to high concentrations of organic solvent can have a narcotic effect (acute); daily exposure to much lower levels can cause liver damage if it continues for many years (chronic). Alcohol is another toxic substance that has both acute and chronic health effects. Specific examples of chemical and biological agents hazardous to health, and outlines of their health effects, are provided later in this element.

REVISION QUESTIONS

1. Give the physical forms of chemicals that may exist in the workplace.
2. Identify the five main health-hazard classifications of chemicals.
3. Distinguish briefly between acute and chronic ill-health effects.

(Suggested Answers are at the end.)

Assessment of Health Risks

KEY INFORMATION

- Hazardous substances enter the body by four main routes: inhalation; ingestion; absorption through the skin; and injection through the skin.
- The body has defence mechanisms that protect it from the entry of hazardous substances and from their harmful effects. The respiratory system is protected by the sneeze reflex, nasal cavity, ciliary escalator and macrophages; the skin also has defence mechanisms.
- Assessing risk from exposure to hazardous substances is a six-step process:
  - Identify the hazardous substances present and the people who might potentially be exposed.
  - Gather information about the substance(s).
  - Evaluate the health risk.
  - Identify any controls needed and implement them.
  - Record the assessment and action taken.
  - Review.
- Product labels, manufacturers' safety data sheets, and exposure limit lists are all relevant sources of information in the assessment process.
- Assessments sometimes require that basic surveys are carried out using equipment such as stain tube detectors, passive samplers, smoke tubes, dust-monitoring equipment and dust lamps.

ROUTES OF ENTRY

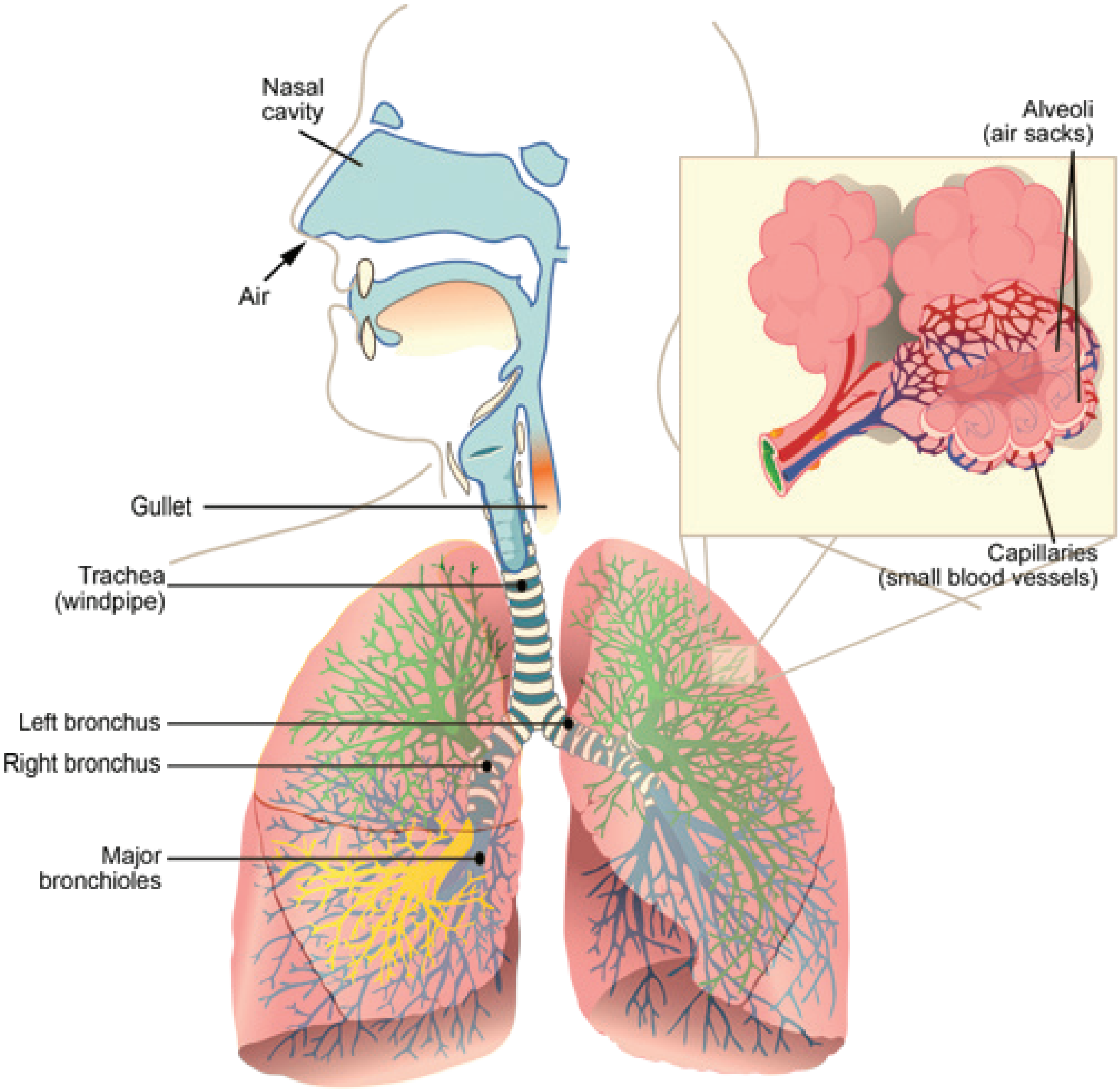
Some hazardous substances cause harm simply by coming into contact with the skin. For example, corrosive chemicals (e.g. hydrochloric acid) cause direct chemical burns to the skin, and irritants and skin sensitisers (e.g. epoxy resin) cause their effects on skin contact.

Many other hazardous substances, however, have to get into the body in some way in order to have a harmful effect.

There are four main routes of entry for hazardous substances into the body:

- **Inhalation** – the substance is breathed in through the nose and mouth and down into the lungs. This is a significant route of entry for many hazardous substances in gas, vapour, mist, fume or dust form. People have to breathe; if the hazardous substance is present in the air around them then it will be inhaled. Dust can be inhaled through the nose and mouth in this way, but not all dust will travel down into the lungs. Dust is made up of small particles of various sizes (diameters). Large dust particles are filtered out by the lungs' defence mechanisms before they can travel down into the lungs; smaller particles are not trapped by these defences and will travel deep into the lungs. These two types of dust are called:
  - **Inhalable dust** – particles of all sizes that can be inhaled into the nose and mouth.
  - **Respirable dust** – particles less than 7 microns (7/1000 mm) in diameter, which can travel deep into the lungs on inhaled breath.
- **Ingestion** – the substance is taken in through the mouth and swallowed down into the stomach and then moves on through the digestive system. This is a less significant route of entry since people are unlikely to deliberately swallow a hazardous substance. Ingestion usually occurs by cross-contamination (of the hands by a toxic substance), or by mistaken ingestion.
- **Absorption through the skin** – the substance passes through the skin and into the tissues beneath and then into the blood stream. Only some substances (e.g. organic solvents) are able to permeate the skin in this way, but when they can this route can be very significant, since any skin contact allows absorption.
- **Injection through the skin** – the substance passes through the skin barrier either by physical injection (e.g. a needle-stick injury) or through damaged skin (cuts and grazes). This route is significant for many biological agents (e.g. hepatitis).

These represent the four main routes of entry, though there are others, such as through the lining of the eye (which has a very rich blood supply) and by aspiration (inhaling a liquid into the lungs).



The Respiratory System

Defence Mechanisms

The body has two main defence mechanisms to combat attack by biological agents and damage by chemicals. These are:

- Cellular defence (internal defence), which allows cells to fight bacteria and other toxins mostly from blood, respiratory and ingestion entry routes.
- Superficial defence (external defence), which protects against toxins that enter through the skin and contaminants in the nose and throat (via collection by the hairs and mucus).

These are some of the basic defence mechanisms.

Respiratory Defences

The respiratory system is made up of the nose and nasal cavity, windpipe (trachea) and lungs. The air passes down the bronchi and bronchioles to the alveoli. These are small air sacs where oxygen enters the bloodstream.

The respiratory system is protected by these defences:

- The **sneeze reflex**.
- **Filtration in the nasal cavity** (which has a thick mucus lining that particles stick to). This is very effective at removing large particles; only particles less than 10 microns in diameter pass through. This mechanism will successfully prevent entry of larger fibres, such as asbestos, and larger particulates in dust, such as silica, but will not prevent smaller asbestos fibres or fine powders, such as cement and finer silica dusts.

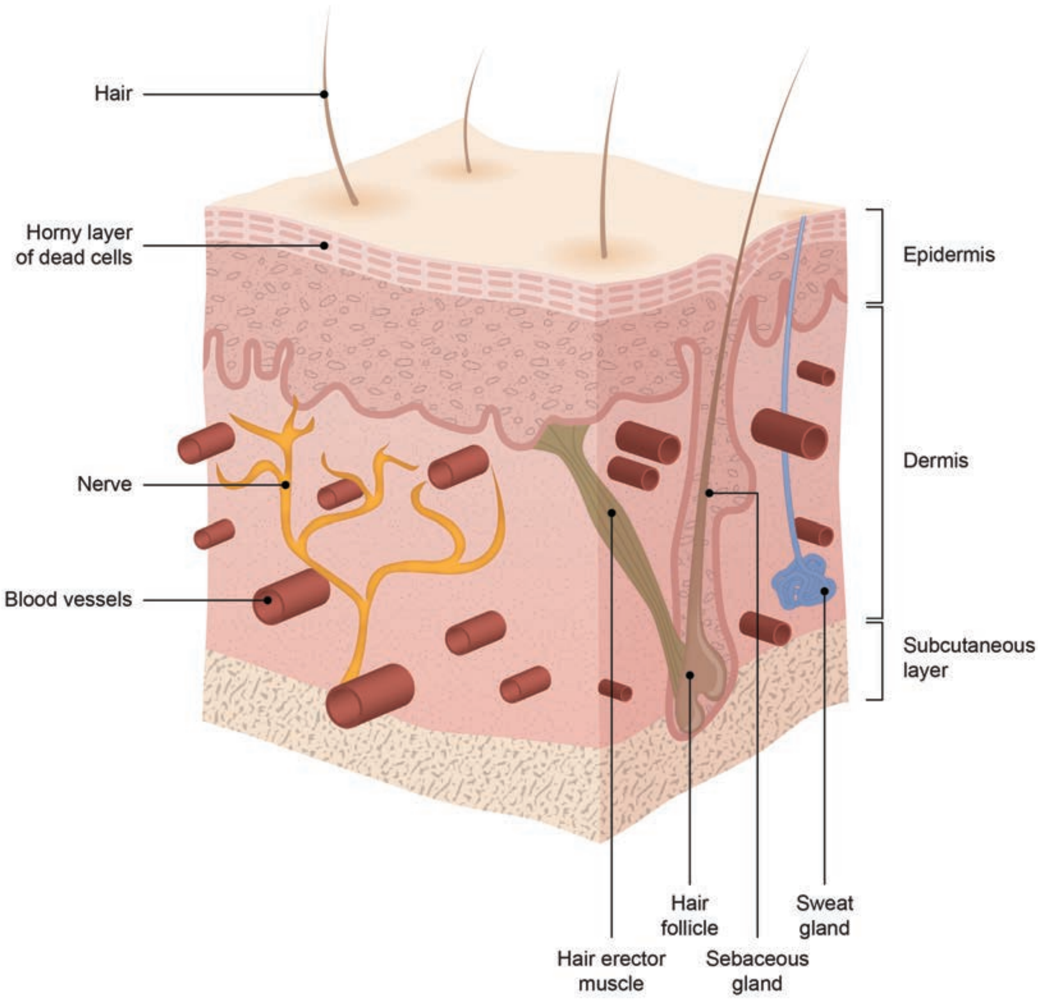
- **Ciliary escalator** – the bronchioles, bronchi and trachea are lined with small hairs (cilia). Mucus lining these passages is gradually moved by these cilia up out of the lungs. Any particles trapped in this mucus are cleaned out of the lungs by this mechanism. This filtration mechanism is effective at removing all particles larger than 7 microns in diameter. This will collect larger asbestos fibres, silica and larger particulates in dust, but, again, will not defend against the finer fibres and particulates.
- **Macrophages/phagocytes** – scavenging white blood cells of irregular outline. They produce enzymes that attack and destroy particles that enter body tissues.
- **Inflammatory response** – any particles that cannot be removed by macrophages are likely to trigger an inflammation response. This causes the walls of the alveoli to thicken and become fibrous. This can be temporary, or may result in permanent scarring (as with silicosis from silica and asbestosis from asbestos fibres).

Skin Defences

The skin forms a waterproof barrier between the body and the outside world. It is made of two layers, the outer **epidermis** and the inner, thicker, **dermis**. Defence mechanisms include:

- A thick layer of dead cells at the surface of the epidermis, which are constantly being replenished as they wear off.
- Sebum – an oily fluid secreted onto the surface of the skin that has biocidal properties.

When damaged, the skin shows an inflammatory response: the area of damage becomes inflamed, swelling occurs, red and white blood cells collect at the site of the damage, and fibrous cross-connections form and scar tissue may result.



Cross-Section of the Skin

ASSESSMENT OF HEALTH RISK

Where workers might potentially be exposed to hazardous substances through the course of their work, it will be necessary to assess that potential to ensure that harm does not occur. Though the exact form of this assessment may vary, depending on local regulation and codes of practice, some general principles can be applied:

- Identify the hazardous substances present and the people who might potentially be exposed.
- Gather information about the substance.
- Evaluate the health risk.
- Identify any controls needed and implement them.
- Record the assessment and action taken.
- Review.

When identifying the hazardous substances present in the workplace, remember that they can be created by work processes. For example, welding metal creates a metal fume; mixing bleach and acid together can create chlorine gas. These hazardous substances do not come pre-packaged and labelled, but are created by the work process.

You can collect together information about hazardous substances by referring to various information sources (see later). The information then has to be used to evaluate the health risks associated with the actual work practices.

All these factors have to be taken into account when undertaking the assessment; the adequacy of any existing control measures can then be decided and additional controls and precautions selected.

TOPIC FOCUS

Factors to consider when carrying out an assessment of health risks include the:

- Hazardous nature of the substance present – is it toxic, corrosive, carcinogenic, etc?
- Potential ill-health effects – will the substance cause minor ill-health or very serious disease, and will these result from short-term or long-term exposure?
- Physical forms that the substance takes in the workplace – is it a solid, liquid, vapour, dust, fume, etc?
- Routes of entry the substance can take in order to cause harm – is it harmful by inhalation, ingestion, skin absorption, etc?
- Quantity of the hazardous substance present in the workplace – including the total quantities stored and the quantities in use, or created at any one time.
- Concentration of the substance – if stored or used neat or diluted, and the concentration in the air if airborne.
- Number of people potentially exposed and any vulnerable groups or individuals – such as pregnant women, or the infirm.
- Frequency of exposure – will people be exposed once a week, once a day or continuously?
- Duration of exposure – will exposure be very brief, last for several hours, or last all day?
- Control measures that are already in place – such as ventilation systems and PPE.

Assessment of Health Risks

SOURCES OF INFORMATION

Information about the nature of a hazardous substance can be obtained from many different sources, but three of the most commonly used sources are product labels, manufacturers' safety data sheets and any relevant exposure limits.

Product Labels

It is becoming more common for labels to be applied that comply with the requirements of more than one country, and classification and labelling of substances is being harmonised through the implementation of the UN **Globally Harmonised System (GHS)**.

Usually, a label will carry the following information:

- The name of the substance/preparation.
- Some idea of the components that make the product hazardous (though this often depends on the overall classification of the product and any provisions for confidentiality or "trade secret" in the country).
- An indication of the danger, which may be by specific warning phrases or symbols, or a combination of both.
- Basic precautions to take (things to avoid, or PPE to wear, etc.).
- Name, address and telephone number of the supplier.

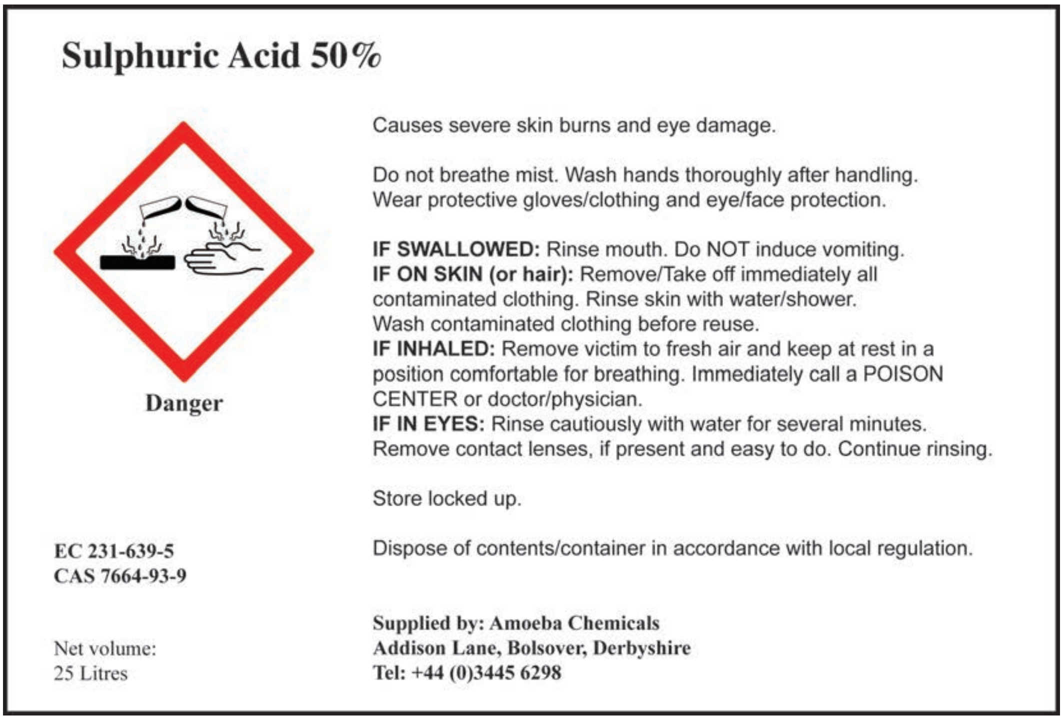
Guidance Documents

Occupational exposure limits are limits on the airborne concentrations of substances to which employees can be exposed; they will be covered in more detail later in this element. Exposure limits vary from one country to another and often have different titles. You can find the national exposure limit for a particular substance by looking in the relevant national guidance documents. For example:

- In the UK, Workplace Exposure Limits are published by the Health and Safety Executive (HSE) in Guidance Note EH40.
- In the USA, Threshold Limit Values are published by the American Conference of Government Industrial Hygienists (ACGIH).
- In the EU, Indicative Limit Values are published by the EU Commission.

Manufacturers' Safety Data Sheets

These are intended to provide end users with sufficient information about a substance for them to take appropriate steps to ensure safe use, including transport and disposal. Legislation requires suppliers of hazardous substances to provide safety data sheets. The basic design and section headings for these documents generally follow a globally-used standard, but the detailed content can vary significantly over the world, since the classification systems also vary.



A label showing the key information about the hazardous nature of the product

TOPIC FOCUS

Safety data sheets contain the following information:

- Identification of the substance or preparation and supplier – including name, address and emergency-contact telephone numbers.
- Composition and information on ingredients – chemical names.
- Hazard identification – a summary of the most important features, including adverse health effects and symptoms.
- First-aid measures – separated for the various risks, and specific, practical and easily understood.
- Fire-fighting measures – emphasising any special requirements.
- Accidental release measures – covering safety, environmental protection and clean-up.
- Handling and storage – recommendations for best practice, including any special storage conditions, or incompatible materials.
- Exposure controls and personal protection – any specific recommendations, such as particular ventilation systems and PPE.
- Physical and chemical properties – physical, stability and solubility properties.
- Stability and reactivity – conditions and materials to avoid.
- Toxicological information – acute and chronic effects, routes of exposure and symptoms.
- Ecological information – environmental effects, which could include effects on aquatic organisms (sea and river life), etc.
- Disposal considerations – advice on specific dangers and legislation.
- Transport information – special precautions.
- Regulatory information – overall classification of the product and any specific legislation that may be applicable.
- Other information – any additional relevant information (e.g. explanation of abbreviations used).

Limitations of Information

The above sources of information are important, but they have limitations in assessing health risk:

- They contain general statements of the hazards. They do not allow for the localised conditions in which the substances are to be used, which will affect the risk.
- The information can be highly technical and therefore meaningless to non-specialists.
- Individual susceptibility to substances varies; a person can be very prone to the health effects of a certain chemical.
- They provide information about the specific substance or preparation in isolation and do not take into account the effects of mixed exposures.
- The information represents current scientific thinking and there may be hazards present that are not currently understood.

Hazardous Substance Monitoring

Many substances are hazardous by inhalation. An obvious question to ask when conducting an assessment of health risk is: 'What is the concentration of this substance in the air?' The only way to answer that question is to undertake some sort of basic survey. Basic surveys use various types of sampling equipment to give an indication of the concentration of a contaminant in air. The role of hazardous substance monitoring might be appropriate to establish:

- When failure or deterioration of the control measures could result in serious health effects.
- When measurement is required in order to be sure that an exposure limit is not exceeded.
- The effectiveness of control measures.
- If adequate control of exposure is no longer being maintained - following process or production changes, for example.

Monitoring can be carried out using various items of equipment, including those described below.

Continuous Monitoring Devices

Monitoring can be carried out using a device that continually samples the environment. Such devices are useful for longer-term monitoring of contaminants and can be highly accurate in determining time-weighted average results.

However, the **disadvantages** are that they:

- Are expensive and considerable training in their use is required.
- May not record peaks and troughs, merely an average.
- May not identify a specific type of contaminant (depending on the design of the equipment and sensors used).
- Can be tampered with by workers to alter the results.
- If used as a static sampler, their results cannot be extrapolated to give results for personal exposure.

GLOSSARY

TIME-WEIGHTED AVERAGE

Average exposure to a contaminant over a specified period of time (usually a nominal eight hours).

Stain Tube Detectors

These are easy to use and useful for analysing gas and vapour contamination in air at one moment in time.

The principle of operation is simple – a known volume of air is drawn through a chemical reagent contained in a glass tube. The contaminant in the air reacts with the reagent and a coloured stain is produced. The degree of staining gives a direct reading of concentration.

The instrument comprises a glass tube containing the chemical reagent fitted to a hand-operated bellows or piston-type pump. Many types of tube are available for detecting different gases and vapours.

The following figure illustrates the principle.

Stain tube before and after use. Note the closed and open ends of the tube. Arrow shows direction of air flow. n=10 indicates that 10 strokes on the hand-bellows are required. These tubes are sensitive to carbon monoxide (CO). Final concentration is given as 50 parts-per-million (ppm).

Stain tubes are quick and cheap to use, require little training and provide an instant result with no additional analysis requirements.

However, their use is **limited**, as they:

- Are only suitable for gases and vapours, not dusts.
- Can be inaccurate.
- Can only be used for grab-sampling and not for taking time-weighted measurements.
- Are fragile.
- Have a limited shelf-life.
- May be used incorrectly.

GLOSSARY

GRAB (OR SPOT) SAMPLING

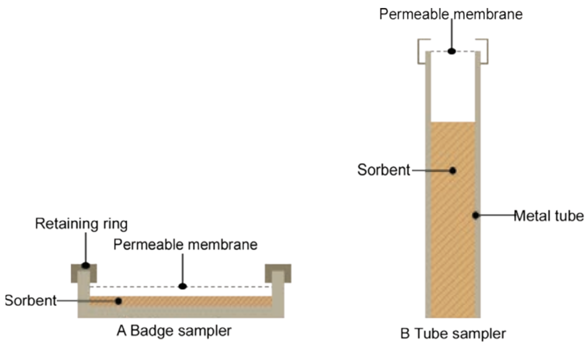
A snap-shot of concentration at one moment in time.

LONG-TERM SAMPLING

An indication of the average concentration of the substance in air over a long sampling period (e.g. over eight hours).

Passive Samplers

These use absorbent chemicals to sample contaminants without using a pump to draw air through the collector. They give a measure of concentration over a period of time (long-term sampling) and can be used for gases and vapours. The sampler is designed to allow gas or vapour to diffuse to an absorbent surface. At the end of the sampling period, the sampler is sent for laboratory analysis (though some work on a colour-change principle similar to litmus paper). The requirement for analysis does make this a more complex and expensive (and slower) process, requiring training in its use. However, the results can be very accurate and can be used to calculate time-weighted measurement results.



Passive (Diffusion) Samplers

Smoke Tubes/Sticks

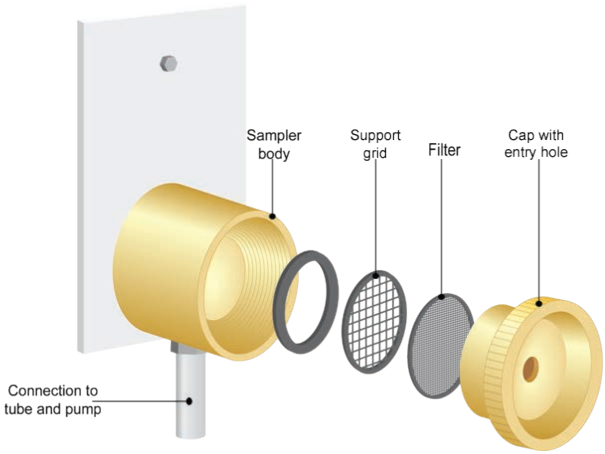
These are simple devices that generate smoke in a controlled chemical reaction. They are similar in appearance to stain tubes and can be used in conjunction with a rubber bulb. Breaking the smoke tube open activates the chemical reaction, then the bulb is used to puff the smoke as required.

Smoke tubes are useful for visualising the movement of air currents in a workplace and, in particular, can be used to assess the effectiveness of ventilation and extraction systems (and to provide general information about air movements).

Dust-Monitoring Equipment

Dust exposure in the workplace can be quantified using a sampling train made up of an air pump, tube and sampling head. This equipment can be worn by a worker, so gives an indication of personal exposure. A pre-weighed filter is fitted into the sampling head, and air is drawn through it by the pump for a chosen period of time; the filter is then removed and re-weighed.

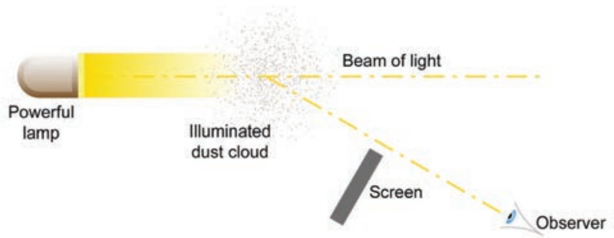
The concentration of dust in the atmosphere can be calculated based on these measurements. This will be an average value over the chosen period of time.



Dust sampler head showing filter in position
(Based on original source MDHS 14/3 General methods for sampling and gravimetric analysis of respirable and inhalable dust, HSE, 2000 (http://www.hse.gov.uk/pubns/mdhs/pdfs/mdhs14-3.pdf))

Dust Lamp (Tyndall Lamp)

Airborne dust in the workplace, which is not visible to the naked eye, can be visualised using a dust lamp.



Tyndall Beam Apparatus

A strong beam of light is shone through the area where a cloud of finely divided dust is suspected. The eye of the observer is shielded from the light beam and the dust cloud is made visible. This method is used to determine how exhaust ventilation systems are working.

Limitations of Hazardous Substance Monitoring

There are several limitations that must be considered before monitoring hazardous substances:

- **Accuracy of results** – monitoring equipment is often limited in its accuracy and variations will occur depending on the time it is used.
- **Variations in personal exposure** – even when careful monitoring has been carried out there may still be variation in employees' personal exposure from the monitoring results owing to personal habits and one-off events.
- **Absence of a standard** – monitoring for its own sake is of no use if there is no occupational exposure limit (OEL) to compare monitoring results to. Not all hazardous substances have an OEL set.
- **Other exposure routes** – monitoring focuses exclusively on airborne contaminant. However, if the substance can be absorbed through the skin, then another route of entry is available and air monitoring may not give a true indication of the actual exposure that is taking place.

REVISION QUESTIONS

4. Identify the routes of entry of chemical and biological agents into the body.
5. What information is generally provided on the label of a substance that has been classified as dangerous?
6. What is the purpose of safety data sheets?
7. Give three limitations in the use of stain tube detectors.
8. What are smoke tubes used for?

(Suggested Answers are at the end.)

Occupational Exposure Limits

KEY INFORMATION

- Occupational exposure limits (OELs) are maximum concentrations of airborne contaminants, normally measured across a particular reference period of time, to which employees may be exposed, usually by inhalation.
- Short-term exposure limits combat the sudden acute effects of exposure; long-term exposure limits combat the long-term chronic effects.
- There are limitations to the effectiveness of OELs in ensuring that employees are not exposed to harmful levels of hazardous substances, and international standards for OELs vary.

WHAT ARE OCCUPATIONAL EXPOSURE LIMITS?

GLOSSARY

OCCUPATIONAL EXPOSURE LIMITS (OELS)
Maximum concentrations of airborne contaminants - normally measured across a particular reference period of time - to which employees may be exposed by inhalation.

There are no harmonised global standards for OELs. The terms used to describe them – as well as definitions, methods for calculating exposures, and the legal status of the limits – vary between countries. It is therefore important to select the correct OEL for the country you are working in and use the correct codes of practice in interpretation (see the guidance documents referred to earlier, for example).

However, the purpose of all OELs is similar – to put a limit in place so that employees will not be exposed to high concentrations of **airborne substances** (either for short durations of time, or for long periods of the working day) where scientific evidence suggests that this would cause a risk to health.

Worker being exposed to airborne contaminant

LONG-TERM AND SHORT-TERM LIMITS

Occupational exposure limits are time-weighted average exposures; in other words, they are calculated by measuring a person's average exposure over a specific reference period of time. They only apply to airborne concentrations of a substance.

The two reference periods of time commonly used are:

- 15 minutes (short-term exposure limit, also known as a STEL). Short-term exposure limits combat the ill-health effects of being exposed to very high levels of the substance for quite short periods of time.
- 8 hours (long-term exposure limit, also known as a LTEL). Long-term exposure limits combat the ill-health effects of being exposed to relatively low concentrations of the substance for many or all hours of every working day, through an entire working lifetime.

The effects of a short-term exposure may be very different from long-term exposure – some substances could be fatal at high concentrations, while others may cause dizziness and have narcotic effects. For example, high concentrations of solvent vapour may cause an employee to become dizzy and possibly unconscious, while longer-term, lower-concentration exposures could result in damage to internal organs, such as the liver.

So, consider an employee working with solvents in a manufacturing process – if they are exposed to short, high-concentration "bursts" of the substance during the process this would be controlled using the STEL, while the long-term, lower-level exposure would be controlled using the LTEL.

SIGNIFICANCE OF TIME-WEIGHTED AVERAGES

A worker can be exposed to different levels of inhalation of a hazardous substance throughout the working day. At some times, they may be exposed to high levels of contaminant; at other times, the exposure level may be low. In many cases, it will not be practical to measure an individual's exposure for all of the working period.

A time-weighted average is equal to the sum of the part of each time period, which is multiplied by the exposure level of the contaminant in that time period. It is then divided by the hours in the working day (usually eight hours) and the level indicated as a time-weighted average (as seen above). That is, the average of all the total exposures in the working day. This can be significant where the concentration of the chemical changes through the day, or the time exposure varies.

LIMITATIONS OF EXPOSURE LIMITS

- OELs are designed only to control the absorption into the body of harmful substances following inhalation. They are not concerned with absorption following ingestion, or through contact with the skin or eyes. So, for example, the concentration of organic solvent in a person's body may be at damagingly high levels, **even though the OEL has not been exceeded**, because most of the solvent may have entered through the skin by direct contact with the liquid solvent rather than by inhalation of solvent vapour.
- They take no account of individual personal susceptibility. This is particularly important in the case of substances that produce an allergic response; once a person has become sensitised, the exposure limit designed to suit the average person has no further validity. Many of the limits have also been established in countries in Europe and the USA and are based on male physiology, so variations due to ethnicity and gender may be significant.
- They do not take account of the synergistic (or combined) effects of mixtures of substances, e.g. the use of multiple substances.
- They may become invalid if the normal environmental conditions are changed, e.g. changes in temperature, humidity or pressure may increase the harmful potential of a substance.
- The organisation may believe that limits are being adhered to but the employees may be working with controls that are no longer effective.
- The monitoring equipment may become contaminated, resulting in inaccurate results.
- Some limits are only "guidelines".
- Some limits do not consider all the possible health effects of a substance, e.g. impact on the skin, such as dermatitis, would not be considered with an airborne limit.

APPLICATION OF RELEVANT LIMITS

As discussed earlier, occupational exposure limits vary between countries:

- In the UK, OELs are known as Workplace Exposure Limits. They are set and published by the regulatory authority (the Health and Safety Executive) and have full legal status.
- In the USA, the term Threshold Limit Values (TLV) is used. These are set and published by the American Conference of Government Industrial Hygienists (ACGIH) and are indicative of good practice but do not have legal status.

The term Maximum Allowable Concentration (MAC) value is often also used internationally. So, as we have said, it is important to be aware of the particular term and definition in use when working internationally.

There are attempts to harmonise these standards. In the EU, Indicative Limit Values (published by the EU Commission) are used as the basis for many countries' limits, but as yet there are no global standards.

COMPARISON OF INTERNATIONAL STANDARDS

As we have seen, different measurements are applied in different regions of the world. In the USA alone, several different groups recommend what occupational exposure limits should be:

- The ACGIH sets Threshold Limit Values (TLVs), as described above.
- The National Institute for Occupational Safety and Health (NIOSH) recommends RELs (Recommended Exposure Limits).
- The American Industrial Hygiene Association (AIHA) has developed WEELs – (Workplace Environmental Exposure Limits).
- Local, state or regional governments also set or recommend their own limits.

As well as these, the Occupational Safety and Health Administration (OSHA) enforces Department of Labor Permissible Exposure Limits (PELs) – which are legal limits in the USA.

The safe levels of exposure set out above may vary due to different time-measuring periods; different measuring criteria (equipment used); different expected airborne concentrations, and various other criteria determining the toxicity of a substance.

Occupational Exposure Limits

The amosite form of asbestos is a good example of how standards differ (this data is provided for illustration only and should not be taken as a definitive list of limits).

- Australia – 1.0 f/ml (fibres per millilitre).
- Belgium – 2.0 f/ml.
- Canada – 0.5 f/ml.
- France – overall asbestos limit of 2.0 f/ml.
- Germany – overall asbestos limit of 1.0 f/ml.
- In the UK, the limit for amosite was set at 0.2 f/ml.
- In the USA, the limit for amosite is set at 0.5 f/ml, with an overall asbestos limit of 2.0 f/ml.

It is therefore important to be aware of the relevant limits when working internationally, and to compare measurements to these exposure limits.

REVISION QUESTIONS

9. Define the term occupational exposure limit.

10. Give two of the limitations of OELs.

(Suggested Answers are at the end.)

Control Measures

KEY INFORMATION

- Exposure to hazardous substances should be prevented or, if this is not possible, controlled below any relevant occupational exposure limit.
- A general hierarchy of controls can be applied to controlling exposure:
  - Eliminate or substitute the substances.
  - Change the process.
  - Reduce exposure time.
  - Enclose or segregate.
  - Local exhaust ventilation.
  - Dilution ventilation.
  - Respiratory protective equipment.
  - Other personal protective equipment
  - Personal hygiene.
  - Health surveillance and biological monitoring.
- Local exhaust ventilation works by extracting airborne contamination from the place where it is created using an inlet hood linked to a filter and fan by ductwork. Such systems have to be inspected and maintained to ensure their ongoing effectiveness.
- Respiratory protective equipment can be subdivided into two groups:
  - Respirators (filtering face-piece, half mask, full face, and power types).
  - Breathing apparatus (air hose, compressed air, and self-contained types).
- Exposure to carcinogens, mutagens and asthmagens should be prevented. Where this is not possible, there is another hierarchy of controls to adopt.

PREVENTION OF EXPOSURE

Preventing exposure to hazardous substances is the most effective way of controlling the health risk that they represent. Where exposure cannot be prevented then it should be controlled. It is possible to apply a hierarchy of controls to substances hazardous to health. In the rest of this section we will be considering prevention of exposure and the associated hierarchy of controls.

COMPLIANCE WITH OCCUPATIONAL EXPOSURE LIMITS

In many countries the relevant OELs have legal status and any breach of the limits might result in enforcement action or be treated as a criminal offence. Where these limit values have no legal status but represent good practice, it is still important to avoid over-exposure. These values are set on the basis of scientific evidence about the levels of exposure that do not cause ill-health.

PRINCIPLES OF GOOD PRACTICE

The following principles of good practice exist with regard to controlling exposure to hazardous substances:

- **Minimisation of emission, release and spread** of hazardous substances through design and operation of processes and task activities. Wherever possible, processes should be modified to remove the hazardous substances altogether, to make use of a less hazardous alternative, or, if that is not possible, a work process should be designed, which controls the substance at source. This can be achieved in many ways, e.g. by totally enclosing the substance so that a worker cannot come into contact with it, or by providing engineering controls, such as extraction.
- **Accounting for relevant routes of entry** into the body when developing control measures for hazardous substances. This will give clear indication of the type of control required, whether personal or collective control is needed, and the level of control necessary (based on toxicity).
- **Exposure control that is proportional to health risk**. Greater resources should be used to combat the greatest hazards; therefore, the level of control will usually be highest for the most hazardous substances.

- **Effectiveness and reliability** of control options that minimise the escape and spread of hazardous substances. Elimination is clearly the most reliable control option, as, once eliminated, the chemical is no longer an issue. However this is not always possible, so other controls must be selected carefully. Controls that rely on the worker to implement them are less likely to be successful, e.g. portable extraction to be used when welding may be forgotten, or used incorrectly.
- **Use of personal protective equipment (PPE)** in combination with other control measures, if adequate control cannot otherwise be achieved. Specifically, respiratory protective equipment may be required if airborne concentrations are still considered too high (e.g. exceeding an OEL).
- **Regular checks and review** of the control measures that are in place to ensure that they remain effective. These control measures should be in place, actually used by workers and maintained in an efficient state. Defects should be reported and corrective actions taken.
- **Provision of information and training** to those working with hazardous substances so that they are fully aware of the risks presented by exposure and the correct measures to minimise those risks.
- Ensuring that any control measures implemented do **not increase the overall risks** to health and safety.

IMPLEMENTING THE PRINCIPLES OF GOOD PRACTICE

Several measures are commonly used to implement the principles outlined above and adequately control exposure.

Elimination or Substitution

It may be possible to eliminate or substitute the substance by:

- Eliminating the process or type of work that requires the use of the substance (e.g. outsourcing a paint-spraying operation).
- Changing the way that the work is done to avoid the need for the substance (e.g. securing with screws rather than gluing).
- Disposing of unused stock of the substance that is no longer required.
- Substituting the hazardous substance by using a non-hazardous one (e.g. switching from an irritant to a non-hazardous floor cleaner).
- Substituting the hazardous substance by using one that has a lower hazard classification (e.g. switching from a corrosive substance to an irritant substance).
- Changing the physical form of the substance to one that is less intrinsically harmful (e.g. massive solid rather than powder).

Process Change

It may be possible to change the process so as to reduce the risks associated with the substance. For example:

- Applying a solvent by brush rather than by spraying reduces airborne mist and vapour.
- Vacuuming rather than sweeping keeps dust levels down.

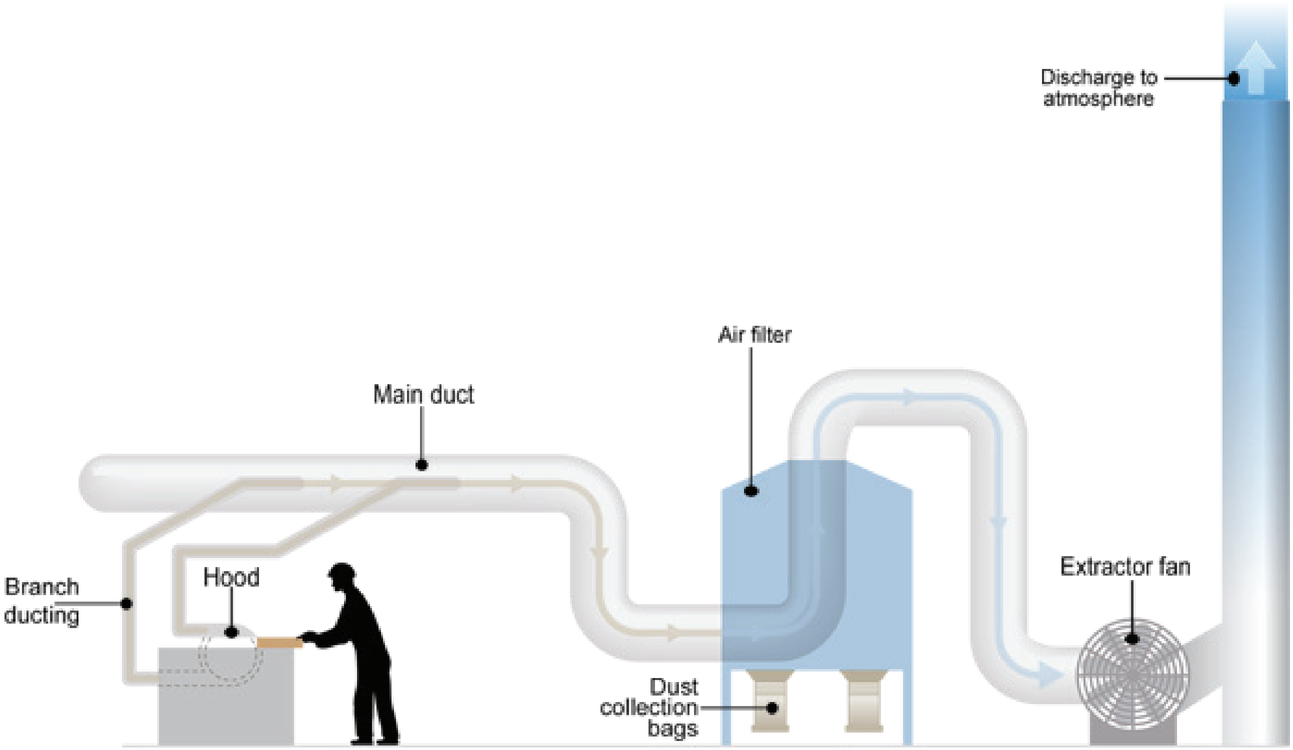
Reduced Exposure Times

There is a simple relationship between the length of time a person is exposed to a hazardous substance and the dose of substance that they receive: double the time, double the dose; half the time, half the dose. It is therefore sensible to minimise the time period over which people work with hazardous substances, especially where those substances can have an acute effect. Exposure may also be limited by occupational exposure limits, which we considered earlier.

Enclosure and Segregation

It may be necessary to totally **enclose** the hazardous substance – inside process machinery, storage tanks, etc. – on a small or large scale. For example, flour dust used in an industrial bakery can be totally enclosed in silos, storage tanks and direct-dosed mixing machinery and moved from one to the other by sealed pipelines. Hundreds of tonnes of flour dust might be handled in this way without the dust escaping into the workplace environment.

Segregating the hazardous substance in the workplace may also be a possibility; it might be stored in a segregated storage area and used in an area away from other work processes and unauthorised personnel.



A typical LEV system extracting sawdust from a bench-mounted circular saw

Local Exhaust Ventilation

One common control for substances that might become airborne is the use of local exhaust ventilation (LEV) systems. A wide variety of different types of LEV is available but the basic principle of an LEV system is the extraction of contaminated air at the point of generation and then the filtering of the contaminant out of the air, allowing the clean air to exhaust to atmosphere.

MORE...

Further information on LEV can be found in the UK HSE publication HSG258 Controlling airborne contaminants at work: A guide to local exhaust ventilation (LEV), available at:

http://www.hse.gov.uk/pubns/books/hsg258.htm

TOPIC FOCUS

A typical LEV system consists of:

- An **intake hood** that draws air from the workplace in the immediate vicinity of the contaminant.
- **Ductwork** that carries that air from the intake hood.
- A **filter system** that cleans the contaminant from the air to an acceptable level.
- A **fan** of some sort that provides the motive force to move the air through the system.
- An **exhaust duct** that discharges the clean air to atmosphere.

A variety of different intake hoods is used on LEV systems, but they can be categorised into two main types:

- **Captor hoods** – capture the contaminant by drawing it into the system by overcoming the contaminant's initial velocity (which may have been taking it away from the hood, such as during grinding).
- **Receptor hoods** – positioned in such a way that the contaminant is moving in that direction already, so less air movement is required to achieve uptake (e.g. a large intake hood suspended above a bath of molten metal; the metal fume will be hot and will rise up into the hood on convection currents).

The **effectiveness** of an LEV system will be **reduced** by:

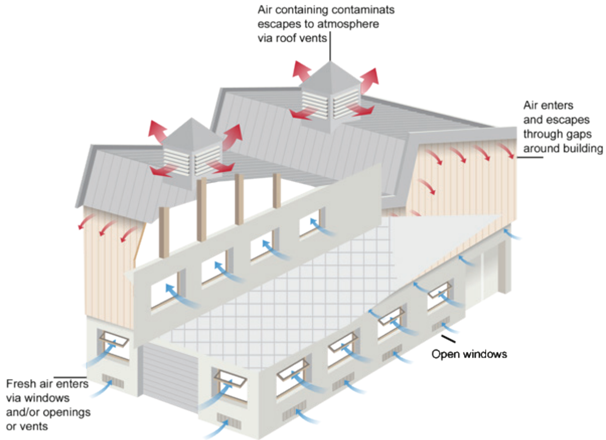
- Poorly positioned intake hoods.
- Damaged ducts.
- Excessive amounts of contamination.
- Ineffective fan due to low speed or lack of maintenance.
- Blocked filters.
- Build-up of contaminant in the ducts.
- Sharp bends in ducts.
- Unauthorised additions to the system.

LEV systems should be routinely inspected and maintained to ensure their ongoing effectiveness. This may include:

- **Routine visual inspection** – to check the integrity of the system, signs of obvious damage and build-up of contaminant both outside and inside the ductwork. Filters should be visually inspected to ensure they are not blocked and the exhaust out-feed should be checked.
- **Planned preventive maintenance** – may include replacing filters, lubricating fan bearings and inspecting the fan motor.
- **Periodic testing** – to ensure that air velocities through the system are adequate. This can be done by visual inspection of the intake hood using a smoke stick, measuring air velocities at the intake and in the ductwork using anemometers, and measuring static pressures using manometers and pressure gauges.

Dilution Ventilation

Dilution ventilation operates by diluting the contaminant concentration in the general atmosphere to an acceptable level by changing the air efficiently in the workplace over a given period of time, e.g. a number of complete changes every hour. These air changes might be achieved **passively** (by providing low-level and/or high-level vents) or **actively** using powered fans.



Passive dilution ventilation

The system is intended to remove gas contaminants (sometimes fumes) and keep the overall concentration of any contaminant to below the OEL.

Dilution ventilation is appropriate where:

- The OEL of the harmful substance is high.
- The rate of formation of the gas or vapour is slow.
- Operators are not in close contact with the contamination generation point.

If a powered system is used fans must be appropriately sited. If the contaminant is:

- **Lighter than air**, it will naturally rise up inside workrooms and can be extracted at a high level.
- **Heavier than air**, it will sink to the floor and low level extraction will be more appropriate.

Limitations of dilution ventilation systems:

- Not suitable for the control of substances with high toxicity.
- Do not cope well with the sudden release of large quantities of contaminant.
- Do not work well for dust.
- Do not work well where the contaminant is released at a point source.
- Dead areas may exist, where high concentrations of the contaminant are allowed to accumulate. These areas remain motionless (owing to the airflow pattern produced by the positioning of extraction fans and the inlets for make-up air used in the ventilation system) and so the air is not changed. Non-moving air is not being mixed and diluted with fresh air and so high levels of hazardous substance can exist in these dead areas.

MORE...

More information about ventilation is available from the UK Health and Safety Executive (HSE) at:

http://www.hse.gov.uk/lev/index.htm

Respiratory Protective Equipment

GLOSSARY

RESPIRATORY PROTECTIVE EQUIPMENT
Respiratory protective equipment (RPE) is any type of personal protective equipment specifically designed to protect the respiratory system, e.g. self-contained breathing apparatus.

Personal protective equipment is often used as a control measure when dealing with hazardous substances. You will know about the general principles of PPE and its uses and limitations from your studies of Unit IGC1. Those general principles can also be applied to respiratory protective equipment (RPE).

There are two main categories of RPE:

- **Respirators** filter the air taken from the immediate environment around the wearer.
- **Breathing apparatus** provides breathable air from a separate source.

Respirators

Respirators are used to remove a contaminant from the air. They **cannot** be used in an environment where there may be a lack of oxygen (as they can only "filter", they cannot "add oxygen"), and they should not be used either to remove a contaminant that is very toxic, or within confined spaces (owing to the potential for the filter to become saturated and the contaminant to "break through" and into the breathing air of the user).
If the material is very toxic, e.g. hydrogen cyanide, then breathing apparatus would be used.

Respirators come in a variety of types:

- **Filtering face-piece respirator** – the simplest type, consisting of a filtering material held over the nose and mouth by an elastic headband.

A worker wearing a filtering face-piece respirator and other PPE

This type of respirator is useful to prevent inhalation of dust (and sometimes gas and vapour), but is not suitable for high concentrations of contaminant, for use against substances with high toxicity, or for long duration use.

Use and benefits	Limitations
Cheap	Low level of protection
Easy to use	Does not seal against the face effectively
Disposable	Uncomfortable to wear

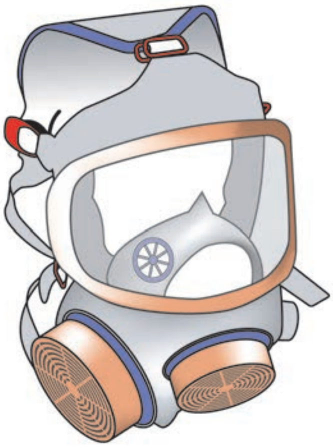
- **Half-mask or ori-nasal respirator** – consists of a rubber or plastic face-piece that fits over the nose and mouth with one or two canisters (cartridges) that contain the filtering material.

A worker wears a half-mask respirator to seal asbestos lagging around a pipe

This gives a much higher level of protection than the filtering face-piece respirator, but does not protect the eyes. Care must be taken to select the **correct filters**.

When the wearer inhales, they create negative air pressure inside the face-piece; this means that any leaks in the respirator (e.g. poor seal against the face, or a split in the rubber) will allow contaminated air in.

Use and benefits	Limitations
Good level of filtration	No built-in eye protection
Good fit achievable	Negative pressure inside face-piece
Easy to use	Uncomfortable to wear



A full-face respirator with filtering canister (or cartridge)

- **Full-face respirator** – similar to the half-mask, but with a built in visor that seals in the eyes and face. Again, care must be taken to select the correct filters.

The full-face respirator gives a high level of protection against airborne contaminants and protects the eyes. This can be important where the contaminant can cause eye irritation or be absorbed through the eye.

Use and benefits	Limitations
Good level of filtration	Restricts vision
Good fit achievable	Negative pressure inside face-piece
Protects the eyes	Uncomfortable to wear

- **Powered respirator** – a powered fan blows filtered air to the wearer. Usually made up of a helmet and face visor with the air blown down over the face from the helmet. As before, care must be taken to select the correct filters.

  This type of respirator does not have a tight seal with the wearer's face and is especially suited to dusty, hot environments, where the stream of air moving over the face is a benefit.

Use and benefits	Limitations
Intermediate level of filtration	Heavy to wear
Air movement cools wearer	No tight face seal
Air stream prevents inward leaks	Limited battery life

Breathing Apparatus

As breathing apparatus (BA) provides a stream of fresh, clean air and does not rely on filters, it can be used in atmospheres where contaminants may be toxic, or where there may be a lack of oxygen. There are several different types of breathing apparatus:

- **Fresh-air hose BA** – the simplest type, where a large-diameter hose is connected to the user's face mask. Air is either:
  - Drawn down the hose by breathing.
  - Blown down by a fan at low pressure.

Use and benefits	Limitations
Air is from outside the work room	Hose must be tethered
Supply of air is not time-restricted	Bends or kinks make breathing difficult
	User is restricted by limited hose length

- **Compressed-air BA** – similar to the fresh-air hose system, but air is supplied down a small-bore hose at high pressure. Pressure is then stepped down by a regulator and supplied at low pressure to the user's face mask.

Use and benefits	Limitations
Supply of air is not time-restricted	Hose can be long, but not endless
Positive pressure inside face-piece	
Wearer is not burdened with cylinder	

- **Self-contained BA** – breathable air is supplied from a pressurised cylinder worn by the user.

Fire-fighter wearing self-contained breathing apparatus

This type of BA gives the wearer complete freedom of movement, but it is the most heavy and bulky type, and the air cylinder does have a limited capacity.

Use and benefits	Limitations
Complete freedom of movement	Supply of air is time-restricted
Positive pressure inside face-piece	Equipment is bulky and heavy
	More technical training is required

Selection, Use and Maintenance

RPE must be selected carefully to ensure that it is suitable.

TOPIC FOCUS

Factors affecting the suitability of RPE:

- Concentration of the contaminant and its hazardous nature.
- Physical form of the substance, e.g. dust or vapour.
- Level of protection offered by the RPE.
- Presence or absence of normal oxygen concentrations.
- Duration of time that it must be worn.
- Compatibility with other items of PPE that must be worn.
- Physical requirements of the job, such as the need to move freely.
- Shape of the user's face and its influence on fit.
- Facial hair that might interfere with an effective seal.
- Physical fitness of the wearer.

The level of protection offered by an item of RPE is usually expressed as the assigned protection factor (APF). This is simply a measure of how well the RPE keeps out the contaminant and is given by the formula:

$$\text{APF} = \frac{\text{Concentration of contaminant in workplace}}{\text{Concentration of contaminant in face-piece}}$$

Any RPE selected must meet relevant standards (e.g. CE marking if it will be used in the EU).

Users of RPE should receive appropriate information, instruction and training. In particular, they should understand:

- How to fit the RPE.
- How to test it to ensure that it is working effectively.
- The limitations of the equipment.
- Any cleaning requirements.
- Any maintenance requirements (e.g. how to change filters).

Arrangements should be made to maintain RPE in line with manufacturers' instructions and any legal standards that might exist. This should include the need to repair or replace damaged items. Maintenance should only be carried out by competent personnel.

Control Measures

Other Personal Protective Equipment

There are other types of personal protective equipment routinely used to give protection against hazardous substances.

Hand Protection

Gloves (short cuff) and gauntlets (long cuff) can give protection against:

- Chemicals, e.g. acids, alkalis, solvents.
- Biological agents, e.g. viruses in blood.
- Physical injury, e.g. knife cuts, with the associated risk of infection.

Where protection against chemicals is concerned, care must be taken to ensure that the gloves are made from a material that is suitable for the chemical in question.

A laboratory worker uses nitrile gloves to prevent contact with chemical reagents being handled in a fume cupboard

Eye Protection

Three different types of eye protection are commonly used to protect the eyes from hazardous substances:

- **Safety spectacles** offer a degree of front and side protection but do not completely encase the eye.
- **Safety goggles** completely encase the eye and offer better splash and impact resistance.
- **Face visors** cover the eyes and face, offering a higher degree of protection.

A face visor offers eye and full face protection in the event of splashes

Body Protection

The body can be protected from hazardous substances by the use of a range of clothing such as:

- Overalls (prevent direct skin contact with agents such as grease).
- Aprons (prevent spills and splashes from getting onto normal work-wear and soaking through to the skin).
- Whole body protection (the entire body is encased in a protective, chemical-resistant suit).

Workers wearing chemical suits respond to an emergency spill

Personal Hygiene and Protection Regimes

Personal hygiene is often critical to prevent exposure to hazardous substances. Many biological agents and some hazardous chemicals get on to the skin or into the mouth by cross-contamination. For example, a laboratory worker's hands become contaminated with bacteria in the lab; they then touch their nose or mouth and the bacteria have direct access. Alternatively, food or cigarettes can be cross-contaminated by hand contact and then put into the mouth.

Without hand-wash facilities this worker is at risk of cross-contamination from chemical and biological agents

It is essential that good hygiene practices are adopted, as appropriate:

- Hand-washing routines when leaving work-rooms.
- Careful removal and disposal of potentially contaminated PPE to prevent cross-contamination of normal clothes.
- Prohibition of eating, drinking and smoking in work areas.

This will require the provision of appropriate washing facilities (water, soap and drying equipment), PPE and work clothes changing facilities, and rest and food preparation areas.

In some instances it may be possible to vaccinate workers against certain biological agents, e.g. vaccination against hepatitis B is often provided to first-aiders on a voluntary basis.

Vaccination can confer immunity against specific biological agents

There are many issues to consider before embarking on a vaccination programme:

- Worker consent must be obtained.
- Vaccination does not always grant immunity.
- Vaccination can give workers a false sense of security.

In most situations, vaccination should only be offered when indicated by law or codes of practice.

Health Surveillance

Health surveillance is a system of ongoing health checks and often involves carrying out some form of medical examination or test on employees who are exposed to substances such as solvents, fumes, biological agents and other hazardous substances.

Health surveillance is important to enable early detection of ill-health effects or diseases, and also helps employers evaluate their control measures and educate employees. The risk assessment will indicate where health surveillance may be needed, but it is required where:

- there is an adverse health effect or disease linked to a workplace exposure; and
- it is likely that the health effect or disease may occur; and
- there are valid techniques for detecting early signs of the health effect or disease; and
- the techniques don't themselves pose a risk to employees.

Two types of health surveillance are commonly carried out:

- **Health monitoring** – the individual is examined for symptoms and signs of disease that might be associated with the agent in question. For example, a worker in a bakery might have a lung function test to check for signs of asthma; flour dust is a respiratory sensitiser capable of causing occupational asthma.
- **Biological monitoring** – a blood, urine or breath sample is taken and analysed for the presence of the agent itself, or its breakdown products. For example, a worker in a car-battery manufacturing plant might have a blood sample taken to test for levels of lead in the bloodstream.

When necessary, health surveillance should be conducted on first employment- to establish a 'baseline'- and then periodically. It can also be done when a person leaves employment as a final check. The need for health surveillance is usually subject to legislation and codes of practice.

MORE...

There is a range of industry-specific guidance on health surveillance available from the UK Health and Safety Executive (HSE) at:

http://www.hse.gov.uk/health-surveillance/resources.htm

TOPIC FOCUS

Types of check which could be included in a health surveillance programme depend on the hazards in the workplace, but may include:

- At a basic level, a health assessment questionnaire.
- Self-checks, or checks by a supervisor (e.g. for skin rashes).
- At a more involved level, a nurse may carry out an examination. This might also be carried out by a doctor (physician) under certain conditions (e.g. sometimes this is required in law, such as for certain radiation workers). Examinations may consist of:
  - Skin checks to look for signs of dermatitis or rashes.
  - Lung function tests (spirometry).
  - Hearing tests (audiometry).
  - Eyesight checks (e.g. for drivers).
  - X-rays and scans (though this is more unusual).
  - Blood tests (if certain hazardous substances are used).

FURTHER CONTROL OF CARCINOGENS, MUTAGENS AND ASTHMAGENS

Exposure to carcinogens, mutagens and asthmagens should be prevented, but if this is not possible then a hierarchy of controls can be adopted:

- Total enclosure of the process and handling systems.
- Prohibition of eating, drinking and smoking in potentially contaminated areas.
- Regular cleaning of floors, walls and other surfaces.
- Designation of areas that may be contaminated (using warning signs).
- Safe storage, handling and disposal.

GLOSSARY

CARCINOGEN

A substance that can induce the growth of malignant tumours (cancer tumours capable of causing serious ill-health or death).

MUTAGEN

A substance that can cause changes (mutations) in the genetic material (DNA) of a cell, leading to heritable genetic defects.

ASTHMAGEN

A substance that is related to the development of asthma symptoms.

REVISION QUESTIONS

11. What principles of control are illustrated by the following measures?
    (a) Using granulated pottery glazes instead of powders.
    (b) Vacuum cleaning rather than sweeping up with a broom.
    (c) Job rotation.
    (d) Using water-based adhesives rather than solvent-based ones.
12. What is the difference between local exhaust ventilation and dilution ventilation?
13. What are dead areas and why are they a problem for dilution ventilation systems?
14. Give the four main types of respirator and the three main types of breathing apparatus.
15. What are the key criteria in the selection of the appropriate respirator to use?
16. What is the main purpose of routine health surveillance?

(Suggested Answers are at the end.)

KEY INFORMATION

- Asbestos causes several serious ill-health conditions: asbestosis, lung cancer, mesothelioma and pleural plaques.
- Removal and disposal of asbestos-containing materials (ACMs) should be strictly controlled and subject to local regulations.
- Other hazardous substances found in workplaces that can cause severe ill-health to those exposed include blood-borne viruses (such as the hepatitis B virus), carbon monoxide, cement, *Legionella* bacteria, *Leptospira* bacteria, silica and wood dust.

ASBESTOS

Asbestos is a generic name given to a collection of naturally-occurring minerals that have been used extensively as fire-resistant building and lagging materials. The three main forms of asbestos are blue (known as crocidolite), brown (amosite) and white (chrysotile). Historically, they have been incorporated into many building parts such as roofs (asbestos cement), ceilings (ceiling tiles), walls and ceilings (in fire breaks), floors (floor tiles), pipes (downpipes), decorative plasters (artex) and insulation (pipe lagging). It may also be found as asbestos rope or gaskets in old equipment such as furnaces, chemical pipework, or boilers.

Health Risks

Asbestos is hazardous by inhalation. Four forms of disease are associated with asbestos exposure:

- **Asbestosis** – asbestos fibres lodge deep in the lungs and cause scar tissue to form. If enough of the lung is scarred then severe breathing difficulties occur. Asbestosis can prove fatal and increases the risk of cancer.
- **Lung cancer** – asbestos fibres in the lung trigger the development of cancerous growths in the lung tissue. Usually fatal.
- **Mesothelioma** – asbestos fibres in the lung migrate through the lung tissue and into the cavities around the lung and trigger the development of cancerous growths in the lining tissue. Always fatal.
- **Diffuse pleural thickening** – thickening of the lining tissue of the lung (sometimes known as pleural plaques) that causes breathing difficulties. Not fatal.

The symptoms of these diseases do not become apparent until years after exposure has occurred (10-15 years for asbestosis and 30-40 years for mesothelioma). Though asbestos use is now banned or seriously restricted in most countries, it remains a serious health risk as it is still present in many buildings. Any work on existing structures where asbestos is present involves the potential to disturb it. Demolition, refurbishment, installation and even minor repair work can expose workers to asbestos by inhalation.

Controls

Where work involves disturbing ACMs (e.g. construction or refurbishment work) then, in most instances, the ACMs should be removed prior to the work commencing. The exact method of removal may vary depending on many factors but it will be subject to national regulations.

In general:

- The work must be notified to the local enforcement agency.
- The work area must be sealed to prevent the escape of air contaminated with asbestos dust.
- Workers entering the sealed area must wear protective clothing and respiratory protective equipment to prevent dust inhalation.
- The sealed area must be ventilated by a negative-pressure ventilation system with high-efficiency particulate-air (HEPA) filters.
- All ACMs removed must be securely double-bagged, labelled and disposed of as a hazardous waste at a site licensed to receive it.

Removal and bagging of ACM

- Monitoring of asbestos dust levels in the air must be carried out both inside and outside the sealed work area.
- Worker exposure must not exceed a specified limit (similar in principle to an OEL).

- The sealed enclosure should only be removed once monitoring has confirmed that asbestos dust levels have dropped below safe limits and clearance has been given.
- Workers must be provided with health surveillance.

Where exposure to asbestos is not planned and occurs unintentionally or unknowingly, then **all work must stop**. Management must be informed immediately of the potential discovery of asbestos, and the precautions outlined above applied.

MANAGING ASBESTOS IN BUILDINGS

The occupiers and owners of buildings should be aware of the presence of asbestos. In some countries there is a legal requirement for them to put in place an asbestos management plan and hold an asbestos register; these will identify locations where asbestos has been found (or could be found), the types of asbestos present and in what amounts it is present.

The asbestos management plan will include a record of regular inspections of the areas containing asbestos, so that its condition can be continually monitored to ensure its deterioration does not become a major risk. While it is left undisturbed, asbestos should cause no harm to workers, providing its presence and locations are known.

OTHER SPECIFIC AGENTS

There are several other commonly encountered chemical and biological agents that are hazardous to health. These are described below, with an outline of the ill-health that they cause and the relevant control measures.

Blood-Borne Viruses

There are many viruses that can be transferred from one person to another by transfer of blood and other body fluids. Perhaps the best known of these blood-borne viruses (BBVs) are hepatitis and Human Immunodeficiency Virus (HIV - the causative agent of Acquired Immune Deficiency Syndrome (AIDS)). Hepatitis presents the greatest risk in the workplace; there are several forms of hepatitis (A, B, C, etc.) caused by different strains of the virus. The route of infection depends on the virus type:

- **Hepatitis A** is contracted orally by cross-contamination with faecal material containing the hepatitis A virus, so sewage workers are at risk.
- **Hepatitis B** is transmitted in body fluids, such as blood, so occupations at risk would include health-care workers (doctors and nurses), fire-fighters, police and waste-disposal workers. The virus survives for long periods outside the body and can survive harsh treatment that would kill other micro-organisms (such as boiling in water). Contaminated body fluids can cause infection by contact with damaged skin, needle-stick injury and even splashing to the eyes and mouth. Symptoms of the disease include jaundice and liver damage. Though many people are able to make a full recovery, others will become long-term sufferers and some continue to carry the virus but do not display any symptoms of infection.

Typical **controls** include:

- Use of PPE (such as gloves and eye protection) when handling potentially contaminated material.
- Correct disposal of potentially contaminated material (such as clinical waste).
- Prevention of needle-stick injuries by correct disposal of sharps in a sharps bin.
- Decontamination and disinfection procedures.
- Vaccination where appropriate.
- Procedures to deal with accidental exposures (e.g. needlestick injuries).

Carbon Monoxide (CO)

A colourless, odourless gas usually encountered as a by-product of partial combustion (e.g. poorly maintained heating boiler). It is hazardous by inhalation.

During normal respiration, oxygen from the atmosphere is absorbed by the red blood cells in the blood and chemically bound to haemoglobin (a protein) so that it can be carried around the circulatory system to body tissues. Carbon monoxide interferes with this oxygen-carrying process by binding onto the haemoglobin molecule at the same place where the oxygen should be (forming a compound called carboxy-haemoglobin). This prevents oxygen transportation and can lead to death by **asphyxiation**.

Low levels of CO (0.005%) will cause a progressively worsening headache. Levels of 1.3% will cause immediate unconsciousness and death within three minutes. Note that this can occur even though oxygen concentrations are normal at 21%.

Typical **controls** include:

- Restricting work on gas systems to competent engineers only.
- Maintenance and testing of boilers and flues.
- Good general workplace ventilation.
- LEV for vehicle exhausts in workshops.
- Care in the siting of equipment containing combustion engines.
- Carbon monoxide alarms.
- Confined-space entry control.

Cement

Cement is used extensively in the construction industry to make mortar and concrete. In its dry powder form it is an **irritant** dust, which is easily inhaled or blown into the eyes. Once mixed with water it is **corrosive** on contact with the skin or eyes.

Workers can be exposed to cement during:

- Mixing operations – in both the dry powder and mixed, wet forms.
- Bricklaying and concrete pouring – in the wet form.

The harmful effects of exposure include:

- Irritation or corrosive burns to the eyes.
- Irritation of the respiratory tract.
- Irritant dermatitis on skin contact.
- Allergic dermatitis on repeated skin contact.
- Corrosive burns to the skin on prolonged contact (sometimes referred to as cementitious burns).

Typical **controls** include:

- Eliminating or reducing exposure.
- Use of work clothing, and PPE such as gloves, dust masks and eye protection.
- Removal of contaminated clothing.
- Good hygiene and washing on skin contact.

Legionella Bacteria

Legionella bacteria are water-loving soil bacteria. The bacteria are hazardous when inhaled into the lungs, where they cause **Legionnaires' disease** (also called legionellosis). This can occur when water systems in a workplace become contaminated with the bacteria and that contaminated water is then sprayed to create a mist (with living bacteria inside the droplets).

The most common sources for outbreaks of the disease are outdoor cooling towers associated with air-conditioning systems. Water containing the bacteria is sprayed inside the cooling tower, then drifts out of the top of the cooling tower and is inhaled by passers-by. These people may then develop the disease.

Symptoms start as flu-like (fever, headache, muscle pain, etc.) and then progress to pneumonia. The disease can prove fatal, especially for the elderly, infirm or immuno-supressed, or if it is not diagnosed early.

Typical **controls** include:

- **Management Controls**
  - Assessment of the risk from *Legionella*.
  - Appointment of a 'responsible person' to carry out risk assessment, manage and implement the controls.
  - Review of control measures.
- **Practical Controls**
  - Avoid water temperatures between 20°C and 45°C and conditions that favour bacteria growth.
  - Avoid water stagnation, which can encourage biofilm growth.
  - Avoid using material that can harbour bacteria and provide them with nutrients.
  - Control the release of water spray.
  - Keep water, storage systems and equipment clean.
  - Use water (chemical) treatments where necessary.
  - Carry out water sampling and analysis.
  - Ensure correct and safe operation and maintenance of water systems.

Leptospira Bacteria

Leptospira bacteria commonly infect animals such as rats, mice, cattle and horses.

Rats are common carriers of the *leptospira* bacteria

Infected rats pass the bacteria in their urine, perhaps onto wet surfaces, or into water where the bacteria can stay alive. If contaminated water comes into contact with cuts or grazes, or is ingested, then infection may occur. Occupations at risk are those who work with potentially infected animals (e.g. dairy farmers), or in wet areas where there may be rats (e.g. sewer workers, water-sports instructors).

The disease **leptospirosis** starts with flu-like symptoms (fever, headache, and muscle pain) and then progresses to a more serious phase involving jaundice. At this stage the disease is causing liver damage and may be known as **Weil's disease**. If diagnosed early the disease is usually treated successfully. It can prove fatal, especially if diagnosed late.

Typical **controls** include:

- Preventing rat infestation, by good housekeeping and pest control.
- Good personal hygiene (e.g. hand-washing).
- PPE (especially gloves).
- Covering cuts and grazes.
- Issuing workers with an "at risk" card to be shown to the worker's doctor (physician) to allow early diagnosis.

GLOSSARY

ZOONOTIC DISEASE (OR ZOONOSES)

A disease that can be passed from animals to humans (e.g. rabies).

Specific Agents

Silica

A component of rock commonly encountered in the mining, quarrying, pottery and construction industries, silica is hazardous by inhalation. When inhaled, respirable crystalline silica dust is deposited deep in the lungs. Over time it causes scar tissue to form (known as silicosis – very similar to asbestosis). This progressive disease leads to breathlessness and chest pain and can prove extremely disabling and fatal (by heart and lung failure).

Typical **controls** include:

- Prevention of exposure by use of alternative work methods.
- Dust suppression by water jet/spray.
- Local exhaust ventilation.
- Respiratory protective equipment.
- Health surveillance (lung-function test and chest X-ray).

Wood Dust

Wood dust is hazardous on inhalation and causes **asthma**. Certain types of wood dust are more likely to cause asthma than others and are therefore categorised as asthmagens. Hardwood dusts can cause cancer (usually of the nose). Again, certain types of hardwood are more strongly associated with risk of **cancer** and are therefore recognised as carcinogens. Workers in the woodworking industry, such as carpenters and joiners, are most at risk of exposure to wood dust, as well as those working in forestry.

Typical **controls** include:

- Local exhaust ventilation systems.
- The use of vacuuming to clean up dust (not sweeping).
- Respiratory protective equipment.
- Health surveillance (usually annual questionnaire).

MORE...

Further information about the health risks and control measures associated with other specific agents is available from the UK Health and Safety Executive (HSE):

http://www.hse.gov.uk/chemicals/index.htm

http://www.hse.gov.uk/asbestos/index.htm

http://www.hse.gov.uk/gas/

http://www.hse.gov.uk/biosafety/infection.htm

http://www.hse.gov.uk/legionnaires/index.htm

http://www.hse.gov.uk/cement/index.htm

http://www.hse.gov.uk/woodworking/index.htm

REVISION QUESTIONS

17. How is carbon monoxide (CO) hazardous to health?
18. Name three diseases associated with asbestos exposure.
19. How is cement hazardous to health?

(Suggested Answers are at the end.)

Safe Handling and Storage of Waste

KEY INFORMATION

- Waste disposal can be managed by adopting a simple hierarchy: waste prevention; prepare for reuse, e.g. by repairing or cleaning; recycling; other recovery; and responsible disposal.
- Employers must fulfil the duty of care that they have to manage hazardous and non-hazardous waste according to legal standards.

WASTE DISPOSAL

GLOSSARY

WASTE

Something that is discarded, or is going to be discarded.

A general approach to waste management can be represented as a hierarchy of principles:

- **Prevention** – eliminating or reducing the quantity of waste produced, e.g. designing products so that they produce no, or less waste in manufacture or use, or considering the repair, re-use and ability to be recycled of the full product or component part.
- **Preparing for reuse** – activities such as repairing, cleaning and checking so that products or components of products may be re-used without any kind of pre-processing.
- **Recycling** – involves some form of treatment to make use of the waste. Compost can be produced by breakdown of plant-matter waste. Glass, metal and paper are all frequently recycled. In recent years, plastics have become more acceptable to recycling as new products have been developed.
- **Other recovery** – using waste as a fuel is an example of a recovery technique. More specifically, this includes burning methane produced from landfill sites to generate energy, or incinerating waste in a waste-to-energy plant.
- **Disposal** – landfill is the key technique, although incineration without energy recovery is also included in this category.

Duty of Care

Waste management is generally controlled through a licensing system, whereby a waste management licence is required by any operator who wishes to keep, treat or dispose of waste. Similarly, all waste disposal sites must be licensed/registered.

The 'duty of care' is applicable to all persons involved in the **generation**, **importation**, **handling**, **transporting** and **disposal** of waste.

It places a responsibility on all of the above to ensure that waste:

- Is managed legally.
- Does not escape from control.
- Is transferred only to an authorised person.
- Is adequately described.
- Is accompanied by appropriate documentation, e.g. a Waste Transfer Note in the UK.

Classification of Waste

- **Hazardous waste** – can be defined as 'waste which may be so dangerous or difficult to treat, keep or dispose of that special provision is required for dealing with it'.

  Wastes are generally defined as hazardous if they are highly flammable, toxic, carcinogenic or corrosive. However, the list also includes many household products such as refrigerators, freezers, televisions, fluorescent-light tubes and computer monitors, which, although not immediately hazardous, may cause longer-term problems.
- **Non-hazardous waste** - refers to materials that are not covered by the above description of hazardous waste and includes household waste, paper, wood and other biodegradable materials.

Each batch of hazardous waste must be accompanied by appropriate documentation (e.g. relating to the amount and content of the waste, and detailing any waste transfer) throughout each stage of the journey, from the producer to final disposal, and the duty falls on the producer to ensure that other duty-holders, such as carriers and disposers, fulfil their duties appropriately.

Safe Handling and Storage of Waste

TOPIC FOCUS

Factors to consider when disposing of waste using a compactor:

- The hazardous nature of the waste.
- The duty of care to dispose of the waste in line with relevant law.
- Any appropriate documentation that should accompany the waste.
- Preventing the waste from escaping from safe storage.
- Keeping the waste segregated from other types of waste.
- Safe loading of the compactor.
- Guarding of moving parts.
- Safe movement of vehicles during collection or unloading.

Worker loading a waste compactor

SAFE HANDLING AND STORAGE

Aside from detailed environmental legislation issues, it is important to consider the health and safety issues associated with the management of waste in a workplace.

Factors to consider include:

- The **hazardous** nature of the waste. It may be inherently hazardous to staff involved in handling it, e.g. toxic or radioactive, and this may require the use of PPE.
- The waste may present a **manual handling** risk. This might be overcome by the use of mechanical handling equipment or handling aids.
- Storage equipment such as skips, bins and compactors may be difficult to **access** and may require steps or platforms to allow safe use.
- Waste containers/skips should be **stored on concrete surfaces** and not on unstable or unmade ground (grass or earth) to prevent contamination of ground and groundwater
- Compactors will have **moving parts** that must be effectively guarded to prevent access.
- Collection **vehicles** such as skip lorries present a significant hazard when manoeuvring, especially when reversing (use a banksman).
- The waste may present a temptation to scavengers (e.g. waste metals) and to vandals (unlocked storage-tank valves) and so must be **secured**.
- Stored **liquid waste** should be contained in either a double-skinned container, or the vessel should be contained in a bund.
- Containers should be **located away** from bund walls.
- Bunds should have the **capacity to store** 110% of the volume of the largest container in the bund.
- Provision should be made to **empty the bund** of rainwater if the storage area is outside (or a roof installed to prevent rainwater ingress).
- Where liquids are pumped, transferred or decanted the **transfer points** or tanker connections should also be contained in a bunded area, or the operation carried out over a drip tray.
- Bunds may need to be **protected from damage**, e.g. by vehicles such as tankers approaching to make deliveries.
- Bunds will need to be **checked and maintained** to ensure that they do not leak.
- Any escape may have the potential to cause **pollution**. Adequately securing the waste might control this risk, but emergency spill or release plans may also be required, along with the necessary personnel, equipment and training to put these plans into effect (see Topic Focus).
- Waste types (**streams**) must be **segregated** to prevent the mixing and contamination of one type of waste with another. This usually requires separate secure storage for each type of waste and the clear identification of types.
- Appropriate **documentation** should accompany the waste and the duty of care - to dispose of waste in line with legal requirements - must be fulfilled.

GLOSSARY

BUND

A wall built around a tank or vessel, which is designed to contain the contents of the tank if it ruptures. The bund wall and base must be impervious to water and should not have any penetrations through it. Bunds can also be portable, pallet-sized trays to contain drum spillages or spills from offloading or decanting (sometimes called "drip trays").

DOUBLE-SKINNED VESSEL

As an alternative to bunding a tank may have an inner and an outer wall. In the event that one is ruptured the other will contain the contents.

TOPIC FOCUS

Spill containment procedures are important wherever liquid pollutants are present. Measures that could be taken include:

- Provision of spill kits featuring booms to contain the spillage, and absorbent granules or pads to soak up the spill (ready for safe disposal).
- Drain covers, which can be used to seal surface water drains.
- Training of operators in the use of the spill kits.

MORE...

http://www.environment-agency.gov.uk/

REVISION QUESTION

20. Name six general hazards that might arise when handling and storing waste for disposal.

(Suggested Answer is at the end.)

SUMMARY

This element has dealt with some of the hazards and controls relevant to hazardous substances in the workplace.

In particular, this element has:

- Outlined the physical forms of chemicals (solids, dusts, fumes, gases, mists, vapours and liquids) and biological agents (fungi, bacteria, viruses, and prions) that can be hazardous to health.
- Identified the classification of hazardous chemicals (toxic, harmful, corrosive, irritant or carcinogenic) and the meaning of the terms "acute" and "chronic" when used to describe their effects.
- Explained the main routes of entry into the body (inhalation, ingestion, absorption through the skin, and injection through the skin).
- Outlined the body's defence mechanisms, including respiratory defences and skin defences.
- Noted some principles for assessing risk from exposure to hazardous substances and the sources of information used (especially product labels, manufacturers' safety data sheets and exposure-limit lists).
- Described some of the equipment that might be used when undertaking basic monitoring to assess concentrations of hazardous substances in the workplace (continuous monitoring devices, stain tube detectors, passive samplers, smoke tubes/sticks, dust monitoring equipment and dust lamps) and their limitations.
- Discussed the principle of occupational exposure limits (OELs) and the use of short-term and long-term exposure limits, as well as international differences and the application of relevant limits.
- Outlined the principles of good practice for controlling exposure.
- Described a hierarchy of controls for hazardous substances: eliminate or substitute; change the process; reduce exposure time; enclose or segregate; local exhaust ventilation; dilution ventilation; respiratory protective equipment; other personal protective equipment; personal hygiene; and health surveillance.
- Outlined basic principles of local exhaust ventilation and dilution ventilation.
- Described types of respiratory protective equipment (filtering face-piece, half-mask, full-face and powered types) and breathing apparatus (air hose, compressed air and self-contained types).
- Explained the ill-health effects of asbestos, various chemicals (e.g. carbon monoxide) and biological agents (e.g. *Legionella*) found in workplaces, and the general controls required.
- Identified basic issues relating to waste disposal, including safe handling and storage.

QUESTION

(a) **Identify THREE** forms of biological agent. (3)

(b) **Identify THREE** possible routes of entry into the body for a biological agent. (3)

(c) **Give TWO** control measures to reduce the risk of exposure to a biological agent. (2)

IGC2, December 2010, Question 4

APPROACHING THE QUESTION

By now you should hopefully be getting quicker at these questions, so try this one in 15 minutes. At this stage, it doesn't matter if it takes you longer but on the day you will need to do each eight-mark question in about eight minutes.

Think now about the steps you would take to answer the question:

1. The first step is to read the question carefully. This question has appeared in this form as an eight-mark question, but also as part of a larger, 20-mark question. Remember the action words – you are required to "identify" and "give" here, so think about the level of detail that this calls for.

2. Next, consider the marks available. You should aim to provide a piece of information for every mark allocated. Here, you have been told exactly how many pieces of information you need to provide for each part of the question. When you are asked for a specific number of pieces of information you shouldn't give more than that as only the first ones will be marked.

3. Now highlight the key words. In this case they might look like this:

   (a) **Identify THREE** forms of **biological agent**. (3)

   (b) **Identify THREE** possible routes of entry into the body for a biological agent. (3)

   (c) **Give TWO** control measures to reduce the risk of exposure to a biological agent. (2)

4. Read the question again to make sure you understand about biological agents and their routes of entry, which should also help you suggest control measures. (Re-read your notes if you have to.)

5. The next stage is to develop a plan – you are now familiar with how to do this.

The answer plan will take the form of a bullet-pointed list that you need to develop into a full answer based on the key words that you have highlighted.

Now have a go at the question. Draw up an answer plan, and then use it as the basis to write out an answer as you would in the exam.

Key hint: Check carefully the type of hazardous agent the question is asking about.

When you have finished, compare your plan and full answer with those that follow.

SUGGESTED ANSWER

Plan

Forms of Biological Agent

Three from:

- Bacteria
- Viruses
- Fungi
- Prions

Routes of Entry

Three from:

- Inhalation
- Absorption
- Ingestion
- Injection

Control Measures

Two from:

- Respiratory protection, e.g. dust masks
- Gloves and goggles
- Good hygiene procedures
- Disinfection and destruction of materials
- Cover wounds
- Immunisation, e.g. hep B

POSSIBLE ANSWER BY EXAM CANDIDATE

15

(a) Common forms of biological agents include bacteria, viruses and fungi.

(b) Three possible routes of entry for a biological agent include inhalation (e.g. of dusts or spores), absorption (through the skin, eyes or mucus membranes), and injection (e.g. through needle-stick injuries).

(c) Two possible control measures include the use of PPE – such as goggles and gloves – to prevent skin and eye contamination with biological agents, or the use of immunisation to provide immunity from infection for some agents, such as hepatitis B vaccinations given to health workers or first-aiders.

REASONS FOR POOR MARKS ACHIEVED BY CANDIDATES IN EXAM

This may look like a daunting question, but it was well answered generally and, as little detail is required, it could prove quite a quick question to answer. By asking about the types of agent, then the routes of entry, the examiners have naturally led candidates to consider control measures.

PHYSICAL AND PSYCHOLOGICAL HEALTH HAZARDS AND RISK CONTROL

ELEMENT 8

LEARNING OUTCOMES

On completion of this element, you should be able to demonstrate understanding of the content by applying what you have learnt to familiar and unfamiliar situations. In particular, you should be able to:

1. Outline the health effects associated with exposure to noise, and appropriate control measures.
2. Outline the health effects associated with exposure to vibration, and appropriate control measures.
3. Outline the principal health effects associated with ionising and non-ionising radiation, and appropriate control measures.
4. Outline the causes and effects of physiological hazards at work, and appropriate control measures.

Contents

Noise

KEY INFORMATION

- Exposure to excessive noise causes noise-induced hearing loss, as well as posing other health and safety risks.
- Noise exposure standards are based on a worker's daily personal noise exposure. An exposure of 85 dB(A) over a work shift is generally considered to be the upper exposure standard.
- Noise exposure should be assessed by undertaking a noise survey using a sound level meter.
- Control of exposure to noise can be achieved by:
  - Reducing the noise at source.
  - Interrupting the pathway from source to receiver.
  - Protecting the receiver using engineering controls/PPE.
- There are two types of hearing protection: ear defenders and ear plugs. Both types have strengths and limitations.
- Health surveillance – in the form of audiometry – is appropriate for workers exposed to high noise levels.

Noise is a significant health hazard in many workplaces.

EFFECTS OF EXPOSURE TO NOISE

There are many health and safety issues associated with being exposed to noise in the workplace.

Physical effects include:

- Temporary reduction in hearing sensitivity as a result of short-duration exposure to excessively loud noise.
- Temporary ringing in the ears as a result of short duration exposure to excessively loud noise.
- Noise-induced hearing loss (NIHL) – permanent loss of hearing as a result of repeated exposure to excessively loud noise.
- Tinnitus – persistent ringing in the ears as a result of repeated exposure to excessively loud noise.
- Inability to hear the following as a result of background noise:
  - Hazards such as vehicles.
  - Alarms and warning sirens.
  - Conversation and spoken instructions.

Psychological effects include:

- Stress – caused by irritating nuisance/background noise.
- Difficulty concentrating and an increase in errors – caused by nuisance/background noise.

Perhaps the most serious effect is noise-induced hearing loss (or industrial deafness). This is usually caused by long-term, repeated exposure to excessively loud noise (though it can be caused by one-off exposure to extremely loud noise).

Exposure to excessively loud noise can have a range of effects

When people are exposed to excessively loud noise, the hearing mechanism itself is damaged. The hearing mechanism transmits noise from the outside environment through the outer and middle ear to the inner ear (the transmission route is ear canal; eardrum; hammer; anvil; stirrup; cochlea). Microscopically small sensory hairs in the inner ear then detect the noise and send nerve impulses to the brain. Exposure to excessively loud noise disturbs these microscopically small hairs.

One-off exposures to high noise levels (e.g. four hours of work in a high-noise area) will probably cause a temporary loss of hearing sensitivity (called 'temporary threshold shift') and temporary ringing in the ears (tinnitus). The microscopically small hairs will have been disturbed, but not damaged beyond repair. Repeated exposures result in permanent threshold shift – irreparable damage – because the sensory hairs are parts of nerve cells that do not regenerate. This is noise-induced hearing loss.

This hearing loss does not normally occur quickly but, over years, as noise exposure continues. The damage is progressive; once it starts any further exposure to excessive noise will result in further damage.

Noise

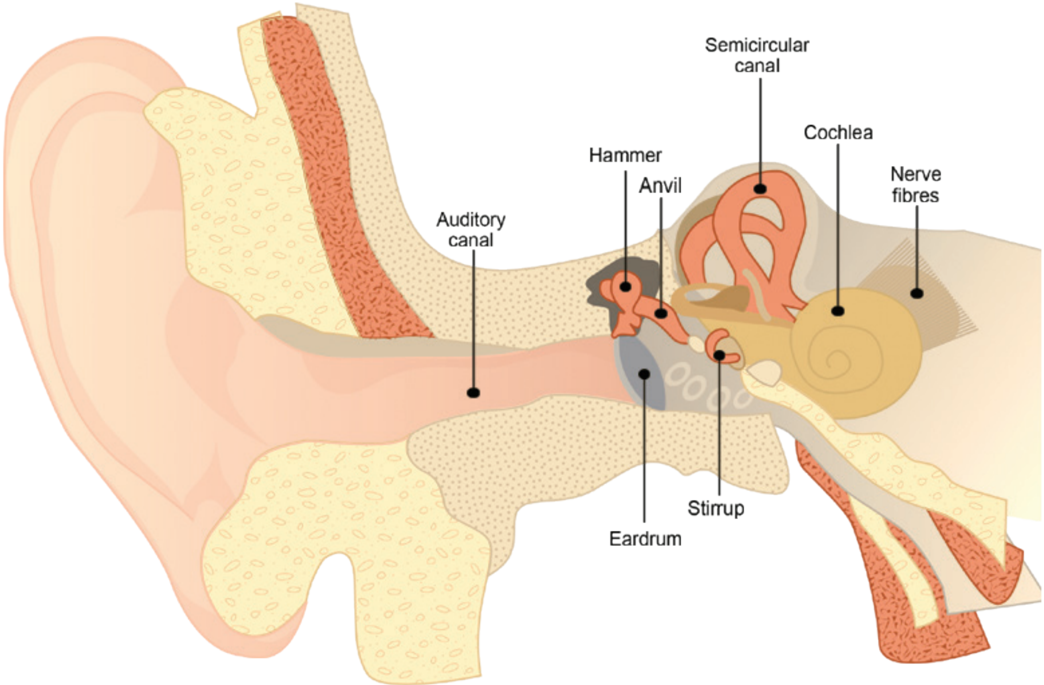


Diagram showing the internal parts of the ear

TERMINOLOGY

The following basic terminology is used in the measurement and assessment of sound:

- **Frequency** – a measure of the number of pressure waves that pass a fixed point in one second (the 'pitch'). The unit used is the hertz (Hz); one hertz is one cycle per second. The human ear is sensitive to noise across a wide range of frequencies: from 20 Hz (very low frequencies – bass) to 20000 Hz (very high frequencies – high pitch).
- **Sound pressure** – the air pressure of sound moving through the air. It can be measured in pascals (Pa) – one pascal is one newton per square metre (Nm^{-2}) – though in reality the decibel (dB) scale is used.
- **Intensity** – a measure of the intensity of the pressure wave or sound energy flow (the 'volume' or 'loudness') moving through the air. It is normally expressed using the decibel (dB) scale.
- **Decibel (dB)** – the unit of sound pressure level (which can be subjectively thought of as the loudness of the noise). The decibel scale is a logarithmic scale; this means that relatively small increases in decibel value actually represent very large increases in intensity. For example, an increase of just 3 dB represents a doubling of sound intensity.
- **A-weighting** – during noise assessment, A-weighting is applied to the decibel scale to give a sound pressure level expressed as dB(A). This A-weighting converts the decibel value to take into account the sensitivity of the human ear across a range of frequencies. In other words, it is the decibel value corrected for the human ear.
- **C-weighting** – during noise assessment, C-weighting may be applied to the decibel scale to give a sound pressure level expressed as dB(C). This C-weighting gives a more accurate reading for impulse noise – single loud bangs that would not be properly recorded using the dB(A) scale.

Measurement in dB(A)	Sound
0	The faintest audible sounds
20-30	Quiet library
50-60	Conversation
65-75	Loud radio
90-100	Power drill
140	Jet aircraft taking off 25m away

Typical decibel levels associated with different noise sources

ASSESSMENT OF EXPOSURE

Because there are levels of noise that can cause damage to the hearing if exposure lasts for a particular period of time, employers must be able to protect their workers from such dangerous levels.

In order to do this, the employer must know what the actual noise level in the workplace is and how long employees are exposed to it. There must be an assessment of both the noise level and time of exposure; a reasonable assessment can then be made of the likelihood of

employees suffering hearing damage. With this information, the employer can go on to put suitable measures in place to control exposure to noise.

Where a noise assessment is needed, some form of noise measurement will probably have to be carried out. Before this is done, information has to be obtained from the workplace (e.g. about the noise sources in the workplace and shift patterns). This background information can then be used to target the measurement and can help in the interpretation of results.

Different types of noise meter that can be used to undertake noise measurement include:

- **Simple sound level meters** – measure instantaneous noise levels and can be used for spot checks, or for very simple surveys.
- **Integrated sound level meters** – measure noise over a period of time and give a time-weighted average over that time period; useful for most noise surveys.
- **Dosimeters** – integrating sound level meters worn by the worker to give a measure of personal noise exposure; useful for work areas where people move around a lot.

The results of a noise survey need to be interpreted to give an accurate estimate of workers' exposures. These exposures can then be compared to the legal standards and any necessary action identified.

Noise measurement and assessment is a complex topic that should only be undertaken by a competent person.

Noise Exposure Limits

Occupational noise exposure is subject to statute law around the world. The law varies between countries and regions, and there are no harmonised standards relating to technical terminology, assessment technique, or regulatory requirements.

However, there is general agreement on the workplace exposure limit for noise: 85 dB(A) daily personal noise exposure.

This exposure limit is set on the basis that the amount of damage done to the ear is dependent on the amount of energy absorbed by the inner ear. This is determined by two factors:

- The noise level (measured in dB(A)).
- The duration of exposure (in hours and minutes).

These two factors determine the "dose" of noise absorbed (a similar principle to hazardous substances and occupational exposure limits, as outlined in Element 7). It is therefore necessary, when undertaking a noise assessment, to measure a worker's actual exposure to noise (which will fluctuate) and then to calculate what the equivalent eight-hour exposure will be.

Though the technical details vary, it is easiest to demonstrate the general principle by considering one regulatory regime: the one used in the EU. Here, two daily personal noise exposure levels are used, putting different legal requirements on the employer:

- **Lower Exposure Action Value = 80 dB(A) daily or weekly personal noise exposure, and a peak sound pressure level of 135 dB(C) for impulse noise.**

  At this value, the employer must:

  – Carry out a noise assessment.
  – Provide information, instruction and training to employees.
  – Make hearing protection available.
- **Upper Exposure Action Value = 85 dB(A) daily or weekly personal noise exposure, and a peak sound pressure level of 137 dB(C) for impulse noise.**

  At this value, the employer must:

  – Carry out a noise assessment.
  – Reduce noise exposure to the lowest level reasonably practicable.

  If noise levels are **still** above 85 dB(A) the employer must:

  – Establish mandatory hearing protection zones.
  – Provide information, instruction and training to employees.
  – Provide hearing protection and enforce its use.
  – Provide health surveillance.
- There may also be Exposure Limit Values as absolute limits, which are:
  – A daily or weekly personal noise exposure of 87 dB(A); and
  – A peak sound pressure of 140 dB(C) for impulse noise.

BASIC NOISE CONTROL MEASURES

Noise exposure can be controlled in three main ways, each of which may be achieved using various methods:

- **Reduce the noise at the source** – completely remove the noise source. This is not practical in many instances, but could involve:
  – **Substituting the source** – changing the noise source for something else that does the same job but generates less noise (e.g. replace a petrol-driven machine with an electric version).
  – **Maintenance** – machinery often produces noise because it is in need of maintenance.
  – **Damping** – machine parts (especially metal surfaces) can sometimes resonate in harmony with noise being produced by the machine (like a cymbal that rings when hit). This exaggerates the noise generated. Damping changes the resonance characteristics of the metal part to prevent it ringing in this way. This can be achieved by changing the part, stiffening it, or even adding material to one side of it.

– **Modifying the process** – e.g. by changing from glass to plastic bottles noise from a packing line can be reduced, or by replacing a compressed-air rivet gun with a screw fixing manufacturing noise can be reduced.
– **Silencing** – any machine that produces exhaust gases (e.g. a diesel generator) should be fitted with a silencer on the exhaust to suppress noise.

- **Interrupt the pathway** from source to receiver through engineering controls, by:
  – **Insulation** – in some instances it is possible to build an acoustic enclosure around the noise source. Noise is generated inside the enclosure but cannot penetrate through the walls to the outside work environment. For example, a static diesel generator might be placed in a separate building with sound insulating walls, or a noisy pump may be enclosed in an acoustic hood.
  – **Isolation** – noise is often transmitted in the form of mechanical vibration from machinery into supporting structures (e.g. from a compressor into the floor it is mounted on). Isolation involves separating the machine from any supporting structure using vibration absorbent mats or springs. This breaks the transmission pathway.
  – **Absorption** – once noise has escaped from its source it may travel directly to the receiver through air, or may be reflected off hard surfaces (such as walls and ceilings). Absorption involves putting sound-absorbing material in the workplace to absorb these sound waves before they can reach the receiver, e.g. a sound-absorbent material might be used to line a wall, preventing reflection of sound waves.
- **Protect the receiver** through engineering controls or PPE:
  – **Acoustic havens** – if the workplace is inherently very noisy and it is not possible to apply the above controls, then an acoustic haven might be built that workers can retreat into to escape the noisy environment.
  – **Hearing protection** – if none of the above are effective or possible, some form of hearing protection should be used to reduce the amount of noise that penetrates to the worker's ear.

GLOSSARY

ENGINEERING CONTROL

A risk control measure that is implemented through the introduction of a 'technical' or 'engineered' solution, e.g. guards, barriers, acoustic booths, extraction systems, etc.

Hearing Protection

Hearing protection prevents harmful levels of noise from reaching the ear.

The two principal types are:

- **Ear defenders or muffs** – encase the outer ear in a cup with some sort of foam or gel-filled cushion to seal against the side of the head.

Advantages of Ear Defenders	Limitations
Easy to supervise and enforce use, as they are visible	Uncomfortable when worn for long time
Less chance of ear infections	Must be routinely inspected, cleaned and maintained
Higher level of protection possible through all sound frequencies; bone transmission is reduced	Efficiency may be reduced by long hair, spectacles or earrings
Can be integrated with other PPE, e.g. hard hats	Incompatible with some other items worn (e.g. spectacles)
Re-usable	Need dedicated storage facility

- **Ear plugs** – fit into the ear canal.

Advantages of Ear Plugs	Limitations
Cheap and easy to use	Difficult to see when fitted, so supervision and enforcement difficult
Disposable	Risk of infection if dirty, or if cross-contaminated when inserted
Available in a range of types and designs	Need to be correctly sized to fit the individual
Often more comfortable to wear	Effectiveness decreases with usage
Do not interfere with any other items worn (e.g. PPE)	Interfere with communication

Various factors must be taken into account when selecting hearing protection, such as noise levels and the strengths and limitations of the various types of protection available. Often one of the most significant factors is the ease of enforcement (ear defenders can be seen from a distance whereas ear plugs cannot). Employees should be involved in the selection process.

Worker using noisy machinery wearing ear defenders

Whichever type of hearing protection is chosen, arrangements should be made for:

- Information, instruction and training - on how to wear the hearing protection; its limitations in use; cleaning, maintenance and replacement arrangements.
- Safe storage - in hygienic locations.
- Cleaning:
  – Ear defenders are often designed to be dismantled for easy cleaning.
  – Ear plugs are usually disposable.
- Maintenance – including routine inspection and replacement of worn parts (e.g. cushions on ear defenders).
- Replacement – of lost or damaged items.

Attenuation

The level of noise able to penetrate to the ear must be assessed to ensure that it is below any relevant exposure limit; to do this, information is required on the:

- Noise characteristics of the workplace (from a noise survey).
- Attenuation characteristics of the hearing protection (the reduction in noise level they give). The attenuation characteristics of the hearing protection come from the manufacturer.

Note that ear defenders can give higher attenuation than ear plugs because some noise can be transmitted through the bone of the skull – this transmission route is partly blocked by defenders but not by plugs. Also note that the attenuation characteristics of hearing protection are measured in laboratory conditions. Ear defenders, in particular, can give lower attenuation in practice because of hair or earrings, which push the ear defender away from the side of the head.

Hair and earrings can stop ear defenders working effectively

THE ROLE OF HEALTH SURVEILLANCE

Health surveillance – in the form of **audiometry** – is appropriate for workers exposed to high noise levels.

GLOSSARY

AUDIOMETRY

A medical test that quantifies the sensitivity of a person's hearing across a range of frequencies (low pitch to high pitch).

It normally involves the worker sitting in a sound-proof booth with headphones on listening for faint beeps and indicating when the beeps can be heard.

The results can show whether a person's hearing is being affected by exposure to loud noise and, if so, to what extent.

Though statutory requirements vary, audiometry should usually be carried out on all workers potentially exposed at or above the 85 dB(A) exposure limit (i.e. those working in mandatory hearing protection areas). It might also be conducted on workers with known hearing damage at lower levels (in the EU, 80 dB(A)).

Any worker who might potentially be exposed to damaging noise levels should be given an audiometry test when they first start work to establish a baseline for their hearing and to indicate whether they have pre-existing damage.

Audiometry allows:

- Identification of workers with:
  - Pre-existing hearing damage.
  - New hearing damage (which may be work-related).
- Removal/exclusion of such workers from high-noise areas (protecting them from further hearing loss).
- Investigation of noise controls to identify and rectify problems (protecting others in the same work area).

Audiometry should be conducted by trained, competent persons, with the possibility of referring cases to a medical practitioner.

OCCUPATIONS AT RISK

The following occupations may be at risk from excessive noise exposure:

- **Construction** workers – as a result of plant and machinery operation, such as concrete-breakers.
- **Uniformed services** – such as army personnel exposed to noise from small arms and artillery fire.
- **Entertainment-sector** workers – such as nightclub staff exposed to loud music.
- **Manufacturing-sector** workers – exposed to industrial machinery noise.
- **Call-centre** staff – exposed to loud nose and acoustic shock from the use of headsets.

MORE...

Further information on controlling exposure to noise is available from the UK Health and Safety Executive (HSE):

http://www.hse.gov.uk/noise/index.htm

REVISION QUESTIONS

1. What does a daily personal exposure of 85 dB(A) mean?
2. What are the limitations of ear defenders and earplugs?

(Suggested Answers are at the end.)

Vibration

KEY INFORMATION

- Exposure to excessive vibration into the hand can cause hand-arm vibration syndrome. Health effects can also be seen for whole-body vibration.
- Exposure standards exist for both hand-arm vibration and whole-body vibration.
- Vibration exposure can be controlled by:
  - Reducing the vibration at source.
  - Interrupting the pathway from source to receiver.
  - Limiting the duration of exposure.
- Health surveillance is appropriate for workers exposed to high vibration levels.

Vibration is similar in many respects to noise, both in terms of its physical characteristics and the control measures used.

EFFECTS OF EXPOSURE TO VIBRATION

The health effects associated with vibration exposure fall into two main categories.

Hand-Arm Vibration Syndrome (HAVS)

This is a condition that specifically affects the hands and arms as a result of a significant vibration dose to the hands.

Symptoms include:

- **Vibration white finger (VWF)** – the blood supply to the fingers shuts down (often in response to cold) and the fingers turn white (known as 'blanching') and become numb. The blood supply returns after a time and the fingers become red and painful.
- **Nerve damage** – the nerves carrying sensory information from the fingers stop working properly resulting in a loss of pressure, heat/pain sensitivity and feeling.
- **Muscle weakening** – grip strength and manual dexterity reduce.
- **Joint damage** – abnormal bone growth can occur at the finger joints.

Typical vibration white finger
Source: L140 Hand-arm vibration, HSE, 2005
(http://www.hse.gov.uk/pubns/priced/l140.pdf)

HAVS normally results from long-term exposure (5 to 10 years, or more) to hand vibration (e.g. from use of a chainsaw). It is an incurable condition. Once damage has been done it is unlikely to reverse, and any further exposure to vibration will do further damage. The most appropriate treatment for most workers is for them to give up the use of vibrating hand-tools.

Whole-Body Vibration Effects

This is a relatively poorly understood area of concern. Health effects can result from a significant vibration dose to the body, normally through the buttocks (when sitting, e.g. dumper-truck driver) or the feet and legs (when standing, e.g. aircraft cabin crew).

The most significant health effect is damage to the soft tissues of the spine (intervertebral discs), though other effects, such as vertigo, have been reported.

ASSESSMENT OF EXPOSURE

As with noise, there are levels of vibration that cause damage to employees who are exposed for a particular period of time. Again, an employer must be able to protect workers from such dangerous levels, and must know what the actual vibration levels associated with equipment are, and also how long employees are exposed to it.

There must be an assessment of both the vibration level and the duration of exposure; then a reasonable assessment can be made of the likelihood of employees suffering damage, such as HAVS or whole-body vibration effects. With this information, the employer can put suitable measures in place to control exposure to vibration.

Vibration

Vibration Exposure Limits

Occupational vibration exposure is subject to statute law in many countries. As with noise, the law varies between countries and regions and there are no harmonised standards for terminology, assessment technique or regulatory requirements.

Exposure limits are set on the basis that the amount of damage done is dependent on the amount of energy absorbed by the body. This is determined by the:

- Vibration magnitude (measured in ms^{-2}).
- Duration of exposure (measured in hours and minutes).

These two factors determine the 'dose' of vibration absorbed (the same principle as applied to noise). When undertaking a vibration assessment it is therefore necessary to estimate a worker's actual exposure to vibration (which will fluctuate) and then calculate what the equivalent eight-hour exposure will be. An assessment might measure vibration exposure directly using a meter (accelerometer), or it might use manufacturers' data.

As with noise, the technical details vary internationally, but again the system used in the EU demonstrates the principles. Two different types of vibration exposure – hand-arm vibration and whole-body vibration – are recognised, and two daily personal vibration exposure levels are set, each putting different legal requirements on the employer:

- **Daily Exposure Action Value = 2.5m.s^{-2} hand-arm vibration / 0.5m.s^{-2} whole-body vibration**

  At this value, the employer must:
  - Carry out a vibration assessment.
  - Reduce vibration exposure to the lowest level reasonably practicable.
  - Provide information, instruction and training to employees.
  - Carry out health surveillance.
- **Daily Exposure Limit Value = 5.0m.s^{-2} hand-arm vibration / 1.15m.s^{-2} whole-body vibration**

  At this value, the employer must:
  - Carry out a vibration assessment.
  - Immediately reduce exposure below the exposure limit value (ELV).

BASIC VIBRATION CONTROL MEASURES

Similar to noise exposure, vibration exposure can be controlled in three main ways:

- **Reduce the vibration at source:**
  - **Eliminate the source** – completely remove the vibration source, perhaps by mechanising the use of tools (e.g. using a concrete-breaker mounted on an excavator arm rather than hand-operated) or by changing work methods (automation of the process, clamping rather than welding, removing the need to grind away welds).
  - **Substitute the source** – change the vibration source for something else that does the same job but generates less vibration. This can be done by changing the type of equipment or tool being used, but can often be achieved by using the same type of tool but simply buying a low-vibration magnitude model.
  - **Change work techniques** – there may be ways of doing the work that do not produce as much vibration (e.g. cutting holes in masonry using a diamond-tipped drill rather than a tungsten hammer drill). It may also be possible to modify the equipment to improve the grip on the tools.
  - **Maintenance** – machinery often produces vibration because it is in need of maintenance. Bits, in particular, should be kept sharp.

This job involves vibration exposure to the hands that must be assessed and controlled

- **Interrupt the pathway from source to receiver:**
  - **Isolation** – vibration is transmitted through solid materials by direct contact (e.g. from the two-stroke motor of a chainsaw to the chassis supporting that motor to the handles to the hands). Isolation involves separating vibrating parts from the user's hands using anti-vibration mountings. This breaks the transmission pathway. This approach can be applied to hand-tools such as chainsaws, and to vehicles - the suspension of a seat in a vehicle cab is isolating the driver from vehicle vibration.
- **Limit the duration of exposure**. There is a direct relationship between vibration dose and duration of exposure: halve the time; halve the dose. This leads to two possible control options:
  - Limit the duration of exposure by calculating how long a worker might use a particular tool before they approach a relevant action or limit value.
  - Change the work schedules, e.g. through job rotation/rest periods, so that vibration exposure is shared between several workers, with no one worker receiving above the relevant action or limit value.

Note that – unlike noise exposure – there is no option to use PPE in order to control vibration exposure. This is because there is conflicting evidence about the effectiveness of PPE at preventing vibration transmission, and many authorities do not recognise PPE as a means of exposure control. In spite of this, hand protection is important when using vibrating hand tools because the hands should be kept warm and dry. Cold, wet hands are more prone to injury from vibration and symptoms are more likely to be experienced, so gloves should be worn to keep the hands warm and dry.

As with all workplace equipment, training is an essential control measure. Operators should be aware of the hazards associated with HAVS and the controls implemented to reduce the risk.

ROLE OF HEALTH SURVEILLANCE

Health surveillance is appropriate for workers exposed to high vibration levels. In the first instance, it might simply consist of looking at a worker's medical history and asking about symptoms of health effects. If problems are detected then tests might be carried out.

Though statutory requirements vary, health surveillance should usually be carried out on all workers potentially exposed at, or above the exposure action value. Any worker who might potentially be exposed to damaging vibration levels should be checked when they first start work to establish a baseline and to indicate whether they have pre-existing damage.

As with noise, health surveillance allows:

- Identification of workers with:
  - Pre-existing damage.
  - New damage (which may be work-related).
- Removal/exclusion of such workers from vibration sources (protecting them from further injury).
- Investigation of vibration controls to identify and rectify problems (protecting others in the same work).

Health surveillance should be conducted by trained, competent persons, with the possibility of referring cases to a medical practitioner.

MORE...

Further information on controlling exposure to vibration is available from the UK Health and Safety Executive (HSE):

http://www.hse.gov.uk/vibration/index.htm

REVISION QUESTION

3. Identify the symptoms of hand-arm vibration syndrome (HAVS).

(Suggested Answer is at the end.)

KEY INFORMATION

- Non-ionising radiation can be categorised as: ultraviolet (UV); visible; infrared (IR); microwave; and radiowave. UV, visible and IR radiation can cause eye and skin damage; microwaves and radiowaves cause internal heating.
- Exposure to non-ionising radiation can be controlled by use of clothing and PPE or by maintaining a safe distance from the source and isolation, SSW and permits.
- Ionising radiation comes in five forms: alpha particles; beta particles; X-rays; gamma-rays and neutrons. Exposure to ionising radiation causes acute sickness and has chronic effects, such as the increased risk of cancer.
- The control of exposure to ionising radiation is based on the principles: time, distance, shielding. Dose limits apply.
- Radon is an alpha particle-emitting form of radioactive gas that can build up to hazardous levels in certain premises. Radon gas levels can be measured and appropriate controls implemented to prevent harmful exposure.
- In order to ensure that radiation controls are properly planned, implemented and monitored, a competent person (or persons) should be appointed in the workplace.
- Workers who are exposed to radiation are at risk of health effects arising from that exposure, so it may be necessary to carry out health surveillance, the precise requirements of which will vary according to national law.

RADIATION: PRINCIPLES AND PRACTICE

Radiation is energy that is emitted by a source.

Radiation can be categorised into many different types, but all of these types belong to two main classes: **ionising** and **non-ionising**.

JARGON BUSTER

IONISING RADIATION
Radiation that causes ionisation in the material that absorbs it.

NON-IONISING RADIATION
Radiation that does not cause ionisation in the material that absorbs it.

Types of Ionising Radiation and Health Effects

There are also several types of ionising radiation:

- **Alpha particles** – sub-atomic particles emitted by some radioactive substances. They do not have much penetrating power and are stopped by thin material such as paper and the dead layer of cells on the surface of the skin. They are not considered particularly hazardous provided the source is outside the body, but very hazardous if the source gets into the body by ingestion or inhalation.
- **Beta particles** – sub-atomic particles emitted by some radioactive substances. They have more penetrating power and can penetrate through the skin into living tissues. Considered hazardous when outside the body.
- **X-rays** – a form of high-energy electromagnetic radiation (light) emitted by some radioactive substances and X-ray generators. They have high penetrating power and can pass right through the human body (though not through dense bone tissue). Considered very hazardous.
- **Gamma-rays** – a form of very high-energy electromagnetic energy (light) emitted by some radioactive substances. They have very high penetrating power and can pass right through the human body (even the bones) and through solid objects such as steel and concrete to a degree. Considered very hazardous.
- **Neutrons** - sub-atomic particles emitted by some radioactive substances. They have very high penetrating power and can penetrate through the body. Considered very hazardous.

(Note that you do not necessarily need to know these technical details, but you do need to remember the names of the types of radiation.)

Acute effects of exposure to high doses of ionising radiation include:

- Radiation sickness - nausea, vomiting and diarrhoea.
- Blistering and ulceration of the skin.
- Hair loss.
- Dermatitis.
- Cataracts.
- Anaemia, due to red blood cell damage.
- Reduced immune system, due to white blood cell damage.
- Infertility.

All of the cells of the body are affected by the radiation, but some more than others. If the dose is large enough then death will follow in weeks, days or hours.

Chronic effects of exposure to ionising radiation include:

- Cancer.
- Genetic mutations.
- Birth defects.

Chronic effects can arise following exposure to high or low doses of radiation. There is no known safe level of exposure below which no chronic effects might occur – instead, there is a clear relationship between dose and the risk of these chronic effects (i.e. the larger the dose the greater the risk).

Types of Non-Ionising Radiation and Health Effects

There are also several types of non-ionising radiation:

- **Ultra-violet (UV)** – high-frequency electromagnetic radiation (light) emitted by white-hot materials such as the arc produced during arc-welding or excessive exposure to the sun.

  Health effects include redness and burns to the skin (e.g. sunburn); pain and inflammation to the surface of the eye, leading to temporary blindness known as photokeratitis (often called arc-eye or snow-blindness); increased risk of skin cancer; premature aging of the skin.
- **Visible light** – electromagnetic radiation between the UV and IR frequencies that is visible to the human eye, arising from artificial lighting and display screens.

  Visible light is particularly dangerous to the eyes (because the retina is very sensitive to it). It can cause temporary blindness if it is intense (disability glare) and permanent eye damage if it is very intense (e.g. from a high-powered laser).
- **Infra-red (IR)** – lower-frequency electromagnetic radiation (light) emitted by red-hot materials, such as molten metal being poured into castings.

  Health effects include redness and burns to the skin; retinal burns, development of eye cataracts over time.
- **Microwaves** – lower-frequency electromagnetic radiation emitted by a microwave generator. (Note that microwaves can be categorised as a subset of radiowaves.)

  Microwaves are absorbed and cause internal heating of the skin. High doses cause internal organ damage and can be fatal.
- **Radiowaves** – lower-frequency electromagnetic radiation emitted by an antenna. Radiowaves are absorbed and cause internal heating in the same way as microwaves.

Lasers are also sources of non-ionising radiation and can operate at UV, visible and IR frequencies (those operating at IR and UV frequencies would not be visible to the eye). Laser light is very coherent – the light waves are all aligned with one another – and the beam does not diverge (spread out) over distance. Laser beams are therefore capable of carrying power over a distance. Lasers are classified according to intrinsic safety and power output. A Class 1 laser presents little risk to workers, but a Class 4 laser can cause instant skin burns and eye damage.

Radon Gas

Radon is a naturally occurring gas that seeps from the ground. High levels of radon gas can be found in certain areas – for example, in the UK, the Derbyshire Peak District and Dartmoor in Devon are high-radon areas owing to their geology.

Radon is a radioactive gas that emits alpha particles. If an atom of radon gas spontaneously decays and emits an alpha particle in air it will not cause significant harm, but if the gas is inhaled into the lungs and then decays, the alpha particle is emitted inside the body and is more likely to be absorbed and cause harm. This effect is made worse because the breakdown product of radon decay is itself a radioactive element, which will undergo further spontaneous decay in the lungs.

Outside – and in well-ventilated workplaces – radon levels are unlikely to be high enough to cause concern. However, in certain places where radon levels are naturally high – and in poorly-ventilated, enclosed workplaces (especially basements and other sub-ground level locations) – they may become high enough to represent a significant risk to health.

The principal ill-health effect associated with radon gas exposure is an increased risk of lung cancer.

OCCUPATIONAL SOURCES OF RADIATION

The possible occupational sources of radiation depend on the type of radiation involved:

- **Sources of Ionising Radiation**

  Ionising radiation is present in a wide variety of workplaces and is used for various applications. Nuclear power stations, scientific laboratories and hospitals are just three typical workplaces where various forms would be encountered. Typical occupational sources include:

  - **Alpha particles** – smoke detectors and science labs.
  - **Beta particles** – science labs and thickness gauges.
  - **X-rays** – medical radiography and baggage security scanners.
  - **Gamma-rays** – industrial radiography.
  - **Neutrons** – nuclear power stations.

- **Sources of Non-Ionising Radiation**

  Non-ionising radiation is present in most workplaces and is used for various applications. Typical occupational sources include:

  - **UV** – sunlight; arc-welding.
  - **IR** – red-hot steel in a rolling mill; glass manufacture.
  - **Visible light** – laser levelling device; laser pointer.
  - **Microwaves** – industrial microwave oven in a food factory; telecommunications equipment (e.g. a mobile phone antenna).
  - **Radiowaves** – radio, TV, or radar antennae.

Fire-fighters will be exposed to high levels of infra-red radiation

- **Sources of Radon**

  Work in any workplaces within the types of geographical regions described earlier can involve exposure to radon. In particular, workers carrying out the following activities could be affected:

  - Geological tasks, e.g. in mining and quarries.
  - Construction and demolition of properties.
  - Farming and outdoor work.

  Instructors in climbing, caving and potholing activities could also be exposed.

CONTROLLING EXPOSURE TO RADIATION

The measures used to control exposure to radiation also depend on the type of radiation involved:

- **Controlling Exposure to Ionising Radiation**

  Protection from ionising radiation can be achieved using three simple principles:

  - **Time** – minimise the duration of exposure. As with noise and vibration, the dose of radiation received is directly proportional to the duration of exposure: halve the duration, halve the dose.
  - **Distance** – the greater the distance from the radiation source to the exposed worker, the lower the dose of radiation received. Alpha and beta particles cannot travel long distances through air, so a relatively small separation distance can have a significant effect. X- and gamma rays travel much greater distances but obey the inverse-square law. This means that if the distance from source to person is doubled, the dose of radiation decreases to a quarter (rather than a half, as you might expect).
  - **Shielding** – the type required will be determined by the type of radiation. Relatively thin shields can be used to contain alpha and beta-particle radiation; X- and gamma-rays require thicker, denser material, such as lead.

Where work potentially exposes people to ionising radiation it may be necessary to assess the dose of radiation received.

The International Commission on Radiological Protection (ICRP) has recommended certain **dose limits** on exposure to ionising radiation (measured in millisieverts (mSv) – a unit of radiation dose). These state that:

- The general public shall not be exposed to more than 1 mSv per year.
- Occupational exposure shall not exceed 20 mSv per year.

These dose limits have been translated into statutory limits in most countries.

Those who are exposed to radiation over a specified national limit may be known as classified workers.

- **Controlling Exposure to Non-Ionising Radiation**

  The basic means of controlling exposure to non-ionising radiation vary depending on the type of non-ionising radiation involved:

  - **UV** – cover exposed skin; protect the eyes. For example, a welder should wear overalls with full-length sleeves to cover the forearms, gauntlets and a full-face welding visor with a dark filter to protect the eyes from UV and intense visible light.
  - **IR** – cover exposed skin; protect the eyes. For example, a metal worker should wear overalls, gauntlets and a face visor, goggles or safety spectacles to protect the eyes.

Workwear and PPE covers all exposed skin, with a dark visor to protect the face and eyes from UV, visible and IR radiations generated during oxy-acetylene cutting

  - **Microwaves and radiowaves** – since these types of radiation can be absorbed internally, the control of exposure is achieved in two main ways:
    - Maintain a safe distance from the source of the radiation (generator or antenna). These types of radiation obey the inverse-square law, so intensity levels drop off very rapidly as distance from the source is increased.
    - Isolate (disconnect the power) and lock off the source if workers have to approach inside safe distances. This is achieved by the use of SSW and permit-to-work systems, and by interlocking sources so that power has to be isolated in order to open access gates/guards.
  - **Lasers** – the degree of protection will depend on the class of laser:
    - Little needs to be done for a low-class laser other than to avoid shining it into people's eyes.
    - For high-class lasers: eye protection (dark goggles); shielding to prevent escape of the beam; use of non-reflective surfaces.

- **Controlling Exposure to Radon**

  Undertaking a survey of radon gas levels will determine if the levels are acceptable, or require action. Where radon levels are shown to be above the action levels established in national law, then it will be necessary to reduce employee exposure.

  Engineering solutions can often be applied to reduce high radon levels, such as installing:

  - Positive-pressure air fans to prevent the radon gas from seeping from the ground up into the workplace.
  - Radon sumps and extraction systems to draw radon out of the ground at a low level before it can seep into buildings.

BASIC RADIATION PROTECTION STRATEGIES

We have already seen that the basic protection strategies involve:

- Shielding.
- Time.
- Distance.

In order to ensure that such controls are properly planned, implemented and monitored, a competent person (or persons) should be appointed in the workplace.

The details of the role may vary internationally. As an example, this role is fulfilled in the UK by a Radiation Protection Supervisor and a Radiation Protection Advisor.

ROLE OF MONITORING AND HEALTH SURVEILLANCE

Workers who are exposed to radiation are at risk of health effects arising from that exposure, so it may be necessary to carry out health surveillance. This is usually conducted by an approved physician.

The precise requirements will vary according to national law, but circumstances requiring health surveillance may include:

- Before an individual begins working as a classified worker (i.e. someone who is exposed to radiation over a specified national limit).
- During periodic health reviews, e.g. annually.
- Special surveillance if a dose limit has been exceeded.
- After an individual ceases work as a classified worker.

Special consideration may also be required for classified workers who are pregnant or breastfeeding.

As part of this health surveillance, the following types of examination may be carried out:

- Skin checks – to identify lesions that could allow radioactive materials to enter the body.
- Respiratory checks – to ensure that workers who may be required to wear respiratory protection are fit and able to do so.
- Reference to exposure records – checking employees' records to determine if dose limits have been exceeded.
- Reference to sickness records – examination of employees' general health and absence history.

MORE...

Further information on radiation is available from the UK Health and Safety Executive (HSE) and Public Health England:

http://www.hse.gov.uk/radiation/index.htm

http://www.hpa.org.uk/Topics/Radiation

REVISION QUESTIONS

4. What type of non-ionising radiation is given off by the following pieces of equipment?
   (a) Radio transmitter.
   (b) Hot plate in a kitchen.
   (c) Arc welder in operation.
   (d) Red light laser.
5. What are the health risks of visible radiation?

(Suggested Answers are at the end.)

Stress

KEY INFORMATION

- Stress is an adverse reaction to excessive pressure. It can cause various psychological, physical and behavioural effects and serious ill-health if prolonged.
- Stress can be caused by: unreasonable demands; lack of control; lack of support; poor working relationships; an ill-defined role; and change. To minimise the risk of serious ill-health caused by stress, the employer should establish a management framework for these factors.

CAUSES, EFFECTS AND CONTROL MEASURES

GLOSSARY

STRESS
The adverse reaction that people have to excessive pressure, or other demands placed on them.

Stress is not a disease but a natural reaction to pressure. Pressure is an inherent part of work, whether it is a deadline that must not be missed, or a rate of output that must be maintained. It does not necessarily lead to stress because, in many circumstances, people are able to cope with the pressure they are under. In fact, in many situations pressure results in a positive performance, e.g. athletes tend to produce their very best performances under the pressure of competition, not in training.

However, in some instances a person finds themselves unable to cope with the pressure that they are under. This leads to anxiety, which then creates a negative reaction, rather than a positive one. If the pressure is short-term then there will be little consequence for the person other than a few sleepless nights. But if the pressure continues or increases, then the relatively minor symptoms of stress can escalate into psychological illness and physical ill-health.

Causes of Stress

We can look at the causes of workplace stress under six headings:

- **Demands** – excessive demands of the job in terms of workload (too much or too little), speed of work and deadlines, as well as working hours (excessively long) and work patterns (e.g. changing shift patterns). Also consider the nature of the job: some jobs are inherently difficult (e.g. air-traffic control) and some expose workers to highly emotional situations (e.g. social work).
- **Control** – lack of control over work, especially where the work is demanding. This includes control over what work is to be done, how it is to be done, the priorities involved and even simple things like control over the working environment (light levels, temperature, background noise, etc.).
- **Support** – lack of support in terms of information, instruction and training to do the work and having no-one to turn to when pressure increases.
- **Relationships** – poor workplace relationships, in particular bullying and harassment (whether by managers, peers, or even subordinates).
- **Role** – lack of clarity about an individual's role, what responsibilities and authority they have, and how they fit in to the larger organisational structure.
- **Change** – the threat of change and the change process itself, whether it is a change that affects just one worker (e.g. demotion, re-assignment) or the whole organisation (e.g. redundancies, management take-over), can create huge anxiety and insecurity.

Excessive workload can be a cause of stress

Non work-related factors are also a very significant cause of stress. Individuals will go through many difficult times in their lives (e.g. bereavement, separation, family illness) that have nothing to do with their work. Also, some individuals will be pre-disposed to anxiety and the negative effects of pressure. Though these factors are not work-related, they still have effects in the workplace, so they do need to be considered.

Physiological Stress

Effects of Stress

Stress can have many effects, some of which will depend on the individual concerned. These effects can be classified as:

- **Psychological** – anxiety, low self-esteem, depression.
- **Physical** – sweating, fast heart beat, high blood pressure, skin rashes, muscle tension, headache, dizziness.
- **Behavioural** – sleeplessness, inability to concentrate, poor decision-making ability, mood swings, irritability, increased alcohol consumption, drug misuse, increased absence from the workplace.

If stress is prolonged and relentless, these effects can lead to the complete physical and mental breakdown of the individual. The consequences for the individual concerned can be extreme: job loss, divorce, alcoholism, drug addiction, etc. The consequences for the employer include increased absenteeism, poor relationships, conflict and higher staff turnover, as well as potential civil legal action.

Stress Control Measures

Since it is not usually possible to remove pressure from the workplace (there will always be deadlines to meet), prevention strategies should focus on providing a basic management framework that takes into account the causes of stress.

- **Demands** – in terms of workload, speed of work and deadlines, etc. - should be reasonable and, where possible, set in consultation with workers. Working hours and work patterns should be carefully selected with reference to guidance and worker preference. Flexible working should be allowed, where possible. The nature of the job should also be considered and workers selected on the basis of their competence, skills and ability to cope with difficult or emotionally-demanding work. Arrangements should be made to allow workers to recover from high stress situations without fear of punishment.
- **Control** – workers should be given as much control of their work as possible, especially where the work is demanding, i.e. encouraged (where possible) to take control over:
  - What work is to be done and how.
  - Priorities
  - The working environment.
- **Support** – workers should be provided with adequate information, instruction and training; they should have access to additional support when they need it.
- **Relationships** – clear policies should exist concerning acceptable standards of behaviour in the workplace; bullying and harassment should not be tolerated.
- **Role** – the organisation should be clear about what an individual's role actually is, their responsibilities and authority, and how they fit in to the larger organisational structure. This should be clearly communicated to the workers and to others across the organisation.
- **Change** – there should be careful planning and preparation of the change process. The reasons for change should be clearly explained and workers consulted where possible. In some situations, change is best done gradually to allow workers to adapt; in others, it is better to implement change quickly to minimise the impact of uncertainty.

Many employers provide a confidential counselling service for employees, which can be provided in-house (by trained employees) or outsourced. This service can be useful to employees in dealing with both work-related and non work-related matters.

MORE...

Further information on stress is available from the UK Health and Safety Executive (HSE):

http://www.hse.gov.uk/stress/index.htm

REVISION QUESTION

6. Give the six work-related causes of stress and, for each, give one example of a preventive measure.

(Suggested Answer is at the end.)

SUMMARY

This element has dealt with some of the health hazards and controls relevant to noise, vibration, radiation and stress.

In particular, it has:

- Explained the physical and psychological effects of exposure to excessive noise, as well as noise exposure standards and basic principles of noise assessment.
- Outlined the control of exposure to noise by reducing the noise at source (substitution, modification, maintenance, damping, silencing), interrupting the pathway from source to receiver (insulation, isolation, absorption) and protecting the receiver using engineering controls/PPE (acoustic havens, hearing protection).
- Discussed the effects of exposure to excessive vibration, as well as exposure standards and basic principles of vibration assessment.
- Outlined the control of vibration exposure by reducing the vibration at source (elimination, substitution, changing techniques, maintenance), interrupting the pathway from source to receiver (isolation) and limiting the duration of exposure.
- Described the types of ionising and non-ionising radiation (as well as radon), their health effects, typical occupational sources and control of exposure.
- Outlined the effects of physiological stress, work-related causes and preventive measures.

QUESTION

(a) **Outline** the possible effects on health from exposure to high levels of noise. (6)

(b) **Outline TWO** noise control techniques that would benefit all workers. (2)

APPROACHING THE QUESTION

By now, you should be getting quicker at these questions, so again try this one in 15 minutes. At this stage, it doesn't matter if it takes you longer, but on the day you will need to do each eight-mark question in about eight minutes.

Think now about the steps you would take to answer the question:

1. The first step is to read the question carefully. In both parts of this question you are asked to "outline" – that gives you an indication of the level of depth required. You should aim to produce a sentence or two about each issue, rather than just a word or two.

2. Next, consider the marks available. You should aim to provide a piece of information for every mark allocated, with six in part (a) and only two in part (b).

3. Now highlight the key words. In this case, they might look like this:

   (a) **Outline** the possible effects on health from exposure to high levels of noise. (6)

   (b) **Outline TWO** noise control techniques that would benefit all workers. (2)

4. Read the question again to make sure you understand about noise and its effects, and possible control measures. (Re-read your notes if you have to.)

5. The next stage is to develop a plan – you are now familiar with how to do this.

The answer plan will take the form of a bullet-pointed list that you need to develop into a full answer based on the key words that you have highlighted.

Now have a go at the question. Draw up an answer plan, and then use it as the basis to write out an answer as you would in the exam.

Key hint: look carefully at part (b) – be **very** clear as to what controls it is asking you to think about!

When you have finished, compare your plan and full answer with those that follow.

SUGGESTED ANSWER

Plan

Health Effects of Noise

- Temporary threshold shift.
- Tinnitus (may be permanent).
- Permanent threshold shift (NIHL).
- Physical damage to ear due to peak noise exposure.
- All results in stress and fatigue.

Controls

- Individual (not required for this question) include hearing protection.
- Collective include reduction at source through use of absorbent enclosures around equipment, use of damping to absorb vibration energy, isolation of equipment.

POSSIBLE ANSWER BY EXAM CANDIDATE

(a) *On exposure to high levels of noise there is a range of health effects which the worker can experience. The cilia (hair cells) in the cochlea can become damaged, resulting initially in a temporary loss of hearing (a temporary threshold shift) with a possibility of tinnitus (ringing in the ears). This effect could ease once the worker leaves the noisy environment. However, repeated exposure could result in this becoming permanent (a permanent threshold shift) and this is what we understand as noise-induced hearing loss, with permanent tinnitus also possible. Workers in noisy environments may also experience stress and fatigue, as their sensory systems are overloaded and they may struggle to concentrate. If the noise is very loud (e.g. gunfire, explosive cartridges, etc.) there is a risk of physical damage to the eardrum and conductive bones in the inner ear.*

(b) *Two possible noise controls that would benefit all workers are:*

- *The use of sound-absorbing enclosures around the equipment, which use foam or mineral wool (or similar) on the inner walls, which absorbs the sound and prevents transmission to the workers.*
- *The use of anti-vibration matting (rubber matting or mounts) placed underneath equipment to absorb energy and prevent vibrations from being transmitted to the surrounding structure, generating noise. These are commonly used underneath pumps and motors.*

REASONS FOR POOR MARKS ACHIEVED BY CANDIDATES IN EXAM

The effects of noise are usually quite well understood, though some candidates only gave "deafness" as a response, which wouldn't have gained the six marks available! In part (b) the examiner was looking specifically for controls which benefit **all** workers, therefore individual controls such as PPE would not be awarded marks.

REVISION AND EXAMINATION

THE LAST HURDLE

Now that you have worked your way through the course material, this section will help you prepare for your NEBOSH examination. This guide contains useful advice on how to approach your revision and the exam itself.

Revision and Examination

YOUR NEBOSH EXAMINATION

There is a separate NEBOSH exam for each unit of the International General Certificate (Unit ICG1 and Unit GC2). Each exam will consist of one question paper which contains one 20-mark question and ten 8-mark questions. You are allowed two hours in which to complete the exam paper and you should answer all the questions.

To pass each exam you must obtain a minimum of 45% of the total marks available.

If your performance is less than the pass mark then you will be "referred". This means you may resit the examination provided you do so within **five years** of the original sitting. You may resit as many times as you want within that five-year timescale.

Be Prepared

It may be some time since you last took an exam.

Remember, success in an exam depends mainly on:

- **Revision** – you have to be able to remember, recall and apply the information contained in your course material; and
- **Exam technique** – you have to be able to understand the questions and write good answers in the time available.

Revision and exam technique are skills that can be learned. We will now look at both of these skills so that you can prepare yourself for the exam. There is a saying that "proper planning and preparation prevents a poor performance". This was never truer than in an exam.

REVISION TIPS

Using the Course Material

You should read through all of the topics at least once before beginning your revision in earnest. This first read-through should be done slowly and carefully.

Having completed this first revision reading of the course materials consider briefly reviewing all of it again to check that you understand all of the elements and the important principles that they contain. At this stage, you are not trying to memorise information but simply checking your understanding of the concepts.

Remember that *understanding* the information and being able to *remember and recall it* are two different things. As you read the course material you should **understand** it; in the exam you have to be able to **remember, recall** and **apply** it. To do this successfully most people have to go back over the material repeatedly.

Re-read the course material and make notes that summarise important information from each element. You could use index cards and create a portable, quick and easy revision aid.

Pay attention to the **Key Information** and **Topic Focus** boxes in this text, but do be aware that these only summarise some of the important points and focus on particular topics. They do not represent the only information that you need to remember.

Check your basic knowledge content of each element by reading the **Summary**. The Summary should help you recall the ideas contained in the text. If it does not, then you may need to revisit the appropriate sections of the element.

Using the Syllabus Guide

We recommend that you purchase a copy of the NEBOSH Guide to this course, which contains the syllabus for your exam. If a topic is in the syllabus then it is possible that there will be an examination question on that topic.

Map your level of knowledge and recall against the syllabus guide. Look at the **Content** listed for each element in the syllabus guide. Ask yourself the following question:

If there is a question in the exam about that topic, could I answer it?

You can even score your current level of knowledge for each topic in each element of the syllabus guide and then use your scores as an indication of your personal strengths and weaknesses. For example, if you scored yourself 5 out of 5 for a topic in Element 1, then obviously you don't have much work to do on that subject as you approach the exam. But if you scored yourself 2 out of 5 for a topic in Element 3 then you have identified an area of weakness. Having identified your strengths and weaknesses in this way you can use this information to decide on the topic areas that you need to concentrate on as you revise for the exam.

You could also annotate or highlight sections of the text that you think are important.

Another way of using the syllabus guide is as an active revision aid:

- Pick a topic at random from any of the elements.
- Write down as many facts and ideas that you can recall that are relevant to that particular topic.

Go back to your course material and see what you missed, and fill in the missing areas.

EXAM HINTS

Success in the exam depends on averaging half marks. or more for each question. Marks are awarded for setting down ideas that are relevant **to the question asked** and demonstrating that you understand what you are talking about. If you have studied your course material thoroughly then this should not be a problem.

One common mistake in answering questions is to go into too much detail on specific topics and fail to deal with the wider issues. If you only cover half the relevant issues, you can only achieve half of the available marks. Try to give as wide an answer as you can, without stepping outside the subject matter of the question altogether. Make sure that you cover each issue in appropriate detail in order to demonstrate that you have the relevant knowledge. Giving relevant examples is a good way of doing this.

We mentioned earlier the value of using the syllabus to plan your revision. Another useful way of combining syllabus study with examination practice is to create your own exam questions by adding one of the words you might find at the beginning of an exam question (such as 'explain' or 'identify' or 'outline') in front of the syllabus topic areas. In this way, you can produce a whole range of questions similar to those used in the exam.

Revision and Examination

BEFORE THE EXAM

You should:

- Know where the exam is to take place.
- Arrive in good time.
- Bring your examination entry voucher, which includes your candidate number, photographic proof of identity, pens, pencils, ruler, etc. (Remember, these must be in a clear plastic bag or wallet.)
- Bring water to drink and sweets to suck, if you want to.

DURING THE EXAM

- Read through the whole exam paper before starting work, if that will help settle your nerves. Start with the question of your choice.
- Manage your time. The exam is two hours long. You should attempt to answer all 11 questions in the two hours. To do this you might spend:
  - 25-30 minutes answering Question 1 (worth 20 marks), and then
  - 8-9 minutes on each of the ten remaining 8-mark questions.

  Check the clock regularly as you write your answers. You should always know exactly where you are, with regard to time.
- As you start each question read the question carefully. Pay particular attention to the wording of the question to make sure you understand what the examiner is looking for. Note the verbs (command words), such as 'describe', 'explain', 'identify', or 'outline' that are used in the question. These indicate the amount of depth and detail required in your answer. As a general guide:
  - 'Explain' and 'describe' mean give an understanding of/a detailed account of something.
  - 'Outline' means give the key features of something.
  - 'Identify' means give a reference to something (could be name or title).
- Pay close attention to the number of marks available for each question, or part of a question – this usually indicates how many key pieces of information the examiner expects to see in your answer.
- Give examples wherever possible, based either on your own personal experience, or things you have read about. An example can be used to illustrate an idea and demonstrate that you understand what you are saying.
- If you start to run out of time, write your answers in bullet-point or checklist style, rather than failing to answer a question at all.
- Keep your handwriting under control; if the examiner cannot read what you have written, then he or she cannot mark it.
- You will not be penalised for poor grammar or spelling, as long as your answers are clear and can be understood. However, you may lose marks if the examiner cannot make sense of the sentence that you have written.

SUGGESTED ANSWERS

NO PEEKING!

Once you have worked your way through the revision questions in this book, use the suggested answers on the following pages to find out where you went wrong (and what you got right), and as a resource to improve your knowledge and question-answering technique.

Question 1

Suitable and sufficient sanitary conveniences (WCs), washing facilities, changing rooms, accommodation for clothing, rest and eating facilities, and access to drinking water.

Question 2

- Provide good workplace ventilation.
- Insulate heat sources.
- Shield heat sources.
- Provide cool refuges.
- Provide easy access to drinking water.
- Provide frequent breaks and job rotation.
- Provide appropriate clothing.

Question 3

- Storage areas should be clearly defined.
- Separate areas should be used for different items (for ease of identification).
- Certain materials and substances should be segregated during storage; alternatively, purpose-built secure storage (e.g. gas-bottle cages) may be required.
- Areas should be kept clean and tidy and should be routinely inspected.
- Appropriate warning signs should be displayed, where necessary (e.g. where flammable materials are stored).
- Storage areas should not be used for work activities.

Question 4

- Hospital accident and emergency staff.
- Police.
- Social workers.
- Bus and taxi drivers.
- Fire-fighters and paramedics.
- Traffic wardens.
- Railway staff.
- Estate agents.

Question 5

General strategies include: clear policy, zero tolerance, training for all staff at risk (handling aggression and violence, defusing situations, break away/self-defence).

Beyond this, two strategies can be adopted, depending on the nature of the work – in particular, whether employees are located in a fixed building, or out in the community:

- Fixed workplace: security guards, security doors, CCTV, screens, panic buttons.
- In the community: customer-vetting, visit-logging, safe system of work, remote supervision, communications.

Question 6

Lateness, absenteeism, poor quality of work, reduced work rate, theft, dishonesty, irritability and mood swings, poor working relationships.

Question 7

- Falls from height.
- Struck by moving, flying or falling objects.
- Struck by a vehicle.
- Striking against a stationary object.

(Only three were required.)

Question 8

- Slip hazards include smooth floor surfaces that are wet or inherently slippery, floors contaminated with a slippery contaminant, and frost and ice.
- Trip hazards include uneven/loose floor surfaces, trailing cables and objects on the floor.

Question 9

- Normal patterns of movement.
- Predictable abnormal movements, such as emergency evacuations.
- Accident history.
- Possible adverse weather conditions, e.g. ice.
- Maintenance requirements.

(Only four were required.)

Question 10

Designated walkways are areas that are specially protected from hazards by segregating people from vehicles, and within which pedestrians should be reasonably safe from harm.

Question 11

- Adequate lighting.
- Use of appropriate footwear with good grip.
- Level floor surfaces.
- Non-slip floor surfaces.
- Good drainage.
- Spill control.
- Use of designated walkways.
- Provision of handrails on steps and stairs.
- Maintenance and repair of defects.
- Use of hi-vis clothing.

(Only eight were required.)

Question 12

The use of roof ladders (or crawling boards) laid across the roof surface, supported by the underlying load-bearing roof members, in order to distribute the load of the worker over a wide area.

Question 13

- Falling from the ladder.
- Tipping or toppling sideways.
- The ladder slipping away from the wall it is propped against.
- Falling objects.

Question 14

To prevent materials from falling in the first place, the following control measures should be used:

- Not stacking materials near edges, particularly unprotected edges.
- Close boarding of working platforms – minimising gaps between scaffold boards, or placing sheeting over the boards so that material cannot fall through.
- Avoiding carrying materials up or down ladders, etc. by using hoists and chutes to move materials.

Question 15

(a) Standards are the vertical tubes (the uprights), ledgers are the horizontal tubes running parallel to the face of the building, and transoms are the tubes spanning across ledgers perpendicular (at right angles) to the face of the building.

(b) Tying secures the scaffolding to the building, whereas bracing is used to stiffen the framework by joining the framework diagonally.

Question 16

Precautions for the use of MEWPs include:

- Firm, level ground for the vehicle to stand on.
- Sufficient clearance from any building or obstacle.
- Barriers in place to provide an exclusion zone, which also prevents collisions with the equipment.
- Adequate edge protection for the cradle.
- Controls of the arm should be inside the cradle.
- Vehicle not moved with the cradle raised unless it is designed for that purpose.
- No overloading.

Question 17

75° to the horizontal (1 out: 4 up ratio).

Question 18

Scaffolds should be inspected:

- When they are first erected.
- After any substantial alteration.
- After any event that may affect their stability, e.g. after being struck by a vehicle, or after high winds.
- Periodically (typically weekly).

Question 19

The main hazards associated with excavations are:

- Collapse.
- Striking buried services.
- People or objects falling in.
- Flooding.
- Hazardous substances.
- Collapse of adjacent structures.

Question 20

Battering is the process of sloping the sides of an excavation at an angle to the floor of the excavation that is shallow enough that the sides do not slip or collapse inwards.

Question 21

The hazards of buried services can be avoided by identifying, as far as possible, the location and nature of all buried services before work starts, planning work to avoid them, marking their location on working plans and on the surface, and through safe digging practices.

Question 22

Inspections should take place before each work shift in the excavation. Additional inspections will be required after any event likely to have affected the strength or stability of the excavation, or after any fall or collapse of material into it.

Unit GC2 – Element 2: Transport Hazards and Risk Control

Question 1

Hazards related to movement of vehicles – loss of control, overturning, and collisions with other vehicles, pedestrians or fixed objects.

Question 2

Several unsafe practices may be involved, including:

- Driving too fast.
- Cornering too fast.
- Driving across a slope (rather than straight up/down)
- Driving with the load elevated.
- Excessive braking.
- Uneven tyre pressures.
- Driving over potholes or kerbs.

Question 3

The main methods of protecting drivers are the use of seat belts, roll bars/cages, or roll-over protective structures (ROPS), and guards to protect the driver in the event of falling objects.

Question 4

Warning lights and alarms should be used to alert pedestrians and other drivers of the approach of a vehicle. They are particularly important at blind corners, junctions and doorways, and on reversing.

Question 5

Means of separating vehicles and pedestrians include:

- Barriers and/or clear surface markings to mark separate routes for pedestrians and vehicles.
- Designated crossing points for pedestrians to use when crossing vehicle routes.
- Separate doorways and access points for pedestrians.

Question 6

Elimination of the need to travel, e.g. by the use of video-conference calling rather than a face-to-face meeting.

Question 7

The driver of the vehicle, the vehicle, and the journey to be made.

Question 8

Risk factors associated with the journey include:

- The route to be taken.
- The schedule for the journey.
- The time allowed for the journey.
- The distance to be travelled.
- Any adverse weather conditions.

(Only three were required.)

Question 1

Adapting the workplace to suit the worker.

Question 2

Fatigue or strain on the eyes, headaches, general fatigue and aches, pains and muscle strains.

Question 3

Posture, forces involved, repetition, duration, twisting, equipment design, environment and recovery time.

Question 4

(a) The work surface or desk should be large enough to hold all necessary equipment and other items used from time to time, and to allow them to be arranged to suit the individual's needs. If necessary, it should also be deep enough to accommodate a VDU for viewing at a comfortable distance without cramping the work surface in front of it.

(b) The keyboard should be of appropriate design to be usable in comfort, with keys of sufficient size and clarity to suit the demands of the task. It should be able to be tilted and separated from the screen so the operator can find a comfortable position.

(c) A work chair must have an adjustable seat back, good lumbar support and be adjustable in height to suit the user.

(d) There should be sufficient clear and unobstructed space at each workstation to enable the work to be done safely, allowing for the manoeuvring and positioning of materials. This should also provide for adequate freedom of movement.

Question 5

The main injuries associated with manual handling are:

- Back injuries, such as slipped discs.
- Work-related upper limb disorders (WRULDs).
- Muscle tears/strains.
- Tendon and ligament injuries/tears/strains.
- Hernias.
- Cuts, burns, dislocation and broken bones.

(Note that "musculoskeletal disorders" is rather too general an answer and covers most of the specific injuries listed above.)

Question 6

WRULD stands for "work-related upper limb disorder" and refers to ill-health conditions affecting the upper limbs, particularly the soft connecting tissues, muscles and nerves of the hand, wrist, arm and shoulder.

WRULDs arise from the repetition of ordinary movements (such as gripping, twisting, reaching or moving), often in a forceful and awkward manner, without sufficient rest or recovery time.

Question 7

The characteristics of a load which constitute a hazard are its weight, size, shape, rigidity (or lack of it), position of its centre of gravity, presence or absence of handles, surface texture, stability of any contents and the contents themselves.

Question 8

The main hazards in the working environment are:

- Space restrictions on movement and posture.
- Conditions of floors and other surfaces.
- Variations in levels.
- Temperature and humidity.
- Strong air movements.
- Lighting conditions.

Question 9

The elimination of risk by automation, or the use of mechanical lifting equipment.

Question 10

- Pregnant women and new mothers.
- Young people.
- People with pre-existing health conditions, such as back injuries.

Question 11

(a) The most common hazard of lift trucks is that, with their small wheels and particularly when loaded and with the forks raised, they may become unbalanced, resulting in them shedding their load, or tipping over. Other hazards arise from the constant need to reverse the truck, obscured vision when the load is raised, and using unsuitable trucks for the working environment.

(b) The main hazards of sack trucks are overloading, instability of the load, tipping when moving over uneven ground or on slopes, and careless stowage.

(c) The main risks associated with lifts and hoists are falls from a height (from a landing level, from the platform, or with the platform) and being hit by materials falling from the platform. Other hazards include being struck by the platform or other moving parts, and being struck by external objects or structures while riding on the platform.

(d) The main hazards associated with cranes are the risk of them becoming unbalanced and toppling over, the arm of the crane swinging out of control or the load striking something while being moved horizontally, or falling.

Question 12

(a) Safety footwear, and perhaps gloves for hand protection while handling loads.

(b) Safety footwear, hard hat, gloves and high-visibility clothing.

Question 13

- Assessment of the ground conditions before siting the crane.
- Using the outriggers.
- Ensuring that the driver is qualified and competent.
- Ensuring that the crane has been maintained and has an in-date report of thorough examination.
- Using a banksman to direct the lifting operation.
- Ensuring that the load is within the lifting capabilities of the crane.
- Making use of any warning devices or indicators fitted to the crane, such as the radius gauge and overload alarm.
- Not using the crane in adverse weather, particularly in high winds.
- Never lifting over a person.

Question 1

Maintenance workers may be at greater risk because during maintenance work:

- Guards have to be removed.
- Safety devices have to be disabled.
- Power sources may be exposed.
- Stored power may be released.
- Access may be difficult.
- Manual handling may be difficult.
- New hazards may be introduced.

Question 2

General health and safety responsibilities of machine operators are to:

- Only operate equipment they are authorised to use.
- Operate equipment in accordance with instruction and training.
- Only use equipment for its intended purpose.
- Carry out all necessary safety checks before using equipment.
- Not use the equipment if it is unsafe.
- Report defects immediately.
- Not use equipment under the influence of drugs or alcohol (including some medication that causes drowsiness).
- Ensure equipment is clean and maintained in safe working order.

Question 3

(a) The risks in the use of hand tools arise from operator error, misuse and improper maintenance.

(b) The additional risks of portable power tools arise from the presence of the power source (and especially the electrical cables) and the speed and force of the tool itself.

Question 4

To identify it for inspection purposes as part of a routine maintenance system, e.g. if the tool is electrically operated it should be given a periodic thorough inspection and test.

Question 5

(a)
- Abrasion on contact with rotating abrasive wheel.
- Drawing in at nip-point between wheel and tool rest.
- Ejection of parts of the wheel during normal use, or if it bursts.
- Entanglement with the spindle on which the wheel is mounted.
- Electricity.
- Hot parts caused by friction (especially the workpiece being ground).
- Health hazard from dust.
- Noise and vibration.

(b)
- Cutting on contact with moving blade.
- Entanglement with moving blade.
- Drawing in at nip-point between blade and casing.
- Puncture by ejected parts (especially broken blade fragments).
- Burns from the hot exhaust system.
- Noise.
- Vibration (into the hands).
- Fire and explosion from petrol (fuel).
- Ergonomic from handling.
- Health hazards from dust, fumes and lubricating oils.

(c)
- Cutting on contact with blade.
- Entanglement with drive motor.
- Drawing in at nip-points between motor and drive belt.
- Ejection of workpiece during cutting.
- Electricity.
- Noise.
- Health hazard from inhalation of wood dust.

Question 6

These occur where a part of the body is caught between two moving parts and drawn into the machine, e.g. drawn in between two counter-rotating rollers in a printing press.

Question 7

Noise, vibration, electricity, temperature, hazardous materials and substances, radiation (both ionising and non-ionising), fire and explosion, slips, trips and falls, and ergonomics.

Question 8

PPE to be worn when using a chainsaw:

- Face (visor) and eye protection (impact-resistant).
- Hearing protection.
- Head protection (hard hat) may be necessary.
- Robust gloves.
- Boots with good grip and steel toe-caps.
- Cut-resistant trousers, or chaps.
- Robust shirt.

Question 9

The hierarchy of protective measures is:

- Fixed guards.
- Other type of guard.
- Protection devices.
- Protection appliances.
- Provision of information, instruction, training and supervision.

Question 10

Interlocking guards:

- Stop the machine immediately when the guard is opened; or
- Will not allow the guard to be opened until the machine has fully stopped, and
- Will not allow the machine to re-start until the guard has been properly closed.

Question 11

Sensitive protective equipment (trip devices) stops the motion of a machine when a person enters the hazard area.

Question 12

There are two potentially serious limitations:

- They can easily be defeated or not used.
- They rely on operators being 100% vigilant in providing for their own safety.

Question 13

These are hand-held tools or devices that are used to hold or manipulate a workpiece as it enters the machine, is worked on, and/or removed from the machine. They allow the operator to keep control of the workpiece while not coming into contact with the hazardous parts of the machine. They include push-sticks, jigs and other types of holder.

Question 14

Before using the tools or machinery.

Question 15

Two people can override the system by each holding one handle.

Question 16

Guarding systems should:

- Be compatible with the process.
- Be of adequate strength.
- Be properly maintained.
- Not increase risk.
- Not be easily bypassed or disabled.
- Allow visibility and ventilation.

Unit GC2 – Element 5: Electrical Safety

Question 1

This is given by Ohm's law:
Voltage = Current x Resistance or V = I x R.

Question 2

An electric shock results in muscle tremor and contractions (often violent). It can also result in the heart beating spasmodically (ventricular fibrillation), or cardiac arrest. It can also result in burns.

Question 3

(i) I = V/R = 230/10,000 = 23 mA. This will cause strong muscle contraction and possibly breathing difficulties.

(ii) I = V/R = 110/10,000 = 11 mA. This will be painful and there will be some muscle contraction.

(iii) I = V/R = 50/10,000 = 5 mA. Perhaps some mild tingling will be felt.

Question 4

Arcing is the electrical bridging through air of one conductor to another. If the arc is connected to a person, the victim may be subject to a burn from the arc and electric shock from the current that passes through the body. There is also a danger of burns from ultraviolet radiation and radiated heat, even where the arc does not actually touch a person. Arcing can also provide a source of ignition for fire.

Question 5

Earthing provides a safe path for any fault current to be dispersed to earth through a low-resistance conductor.

Question 6

A fuse forms a weak link in a circuit by overheating and melting by design if the current exceeds the safe limit. A circuit-breaker is an electro-mechanical device in the form of a switch, which automatically opens if the circuit is overloaded.

Question 7

Switching off refers to depriving the equipment of electric power, but still leaving it connected. Isolation refers to physically separating it from any source of electric power, with the additional step being taken of ensuring that it cannot be inadvertently re-energised.

Question 8

Reduced low-voltage circuits reduce the effect of any shock received from making contact with part of the circuit because of the relationship between voltage and current. If resistance stays the same, then less voltage means less current.

Question 9

If they cannot be powered by battery, then a residual current device should be used.

Question 10

The user should visually check for signs that the equipment is in good condition. They should look for:

- Damage to the cable sheaths, joints or plugs.
- Evidence that the equipment has been subjected to conditions for which it is not suitable, e.g. it is wet or excessively contaminated.
- Damage to the external casing of the equipment, or loose parts, or screws.

Unit GC2 – Element 6: Fire Safety

Question 1

(a) Friction is the process whereby heat is given off by two materials moving against one another. In the absence of a lubricant or cooling substance it can result in the surfaces of the materials becoming hot or actually producing sparks, either of which may be sufficient to cause ignition.

(b) A space heater is designed to give off considerable heat and, close to the heater, temperatures may be very high. Fire may be started by combustible materials being placed too close to the source of the heat (through radiation), or by obstructing the air intake into the heater.

Question 2

The smoke may begin to clear, but by allowing fresh air into an oxygen-depleted environment the fire is likely to burn with increased intensity.

Question 3

(a) Class C – fires involving gases.
(b) Class B – fires involving flammable liquids.
(c) Class A – fires involving solid, mainly carbonaceous, materials (here, most likely paper and furniture, etc.)

Question 4

(a) Convection.
(b) Radiation.
(c) Conduction.

Question 5

Direct burning.

Question 6

The five steps of fire risk assessment are:

- Identify the fire hazards:
  - Sources of fuel.
  - Sources of ignition.
  - Sources of oxygen.
- Identify the people who might be harmed:
  - People in the premises.
  - Vulnerable people.
- Identify and implement the required fire precautions:
  - Fire prevention.
  - Prevention of the spread of smoke and flames.
  - Fire detection and alarm.
  - Fire-fighting equipment.
  - Means of escape.
  - Signs and notices.
  - Lighting.
- Record findings, plan and train:
  - Emergency plans.
  - Information and instruction.
  - Training.
- Review and revise as necessary.

Question 7

Fire risk can be minimised by ensuring that wood shavings and dust are cleared regularly and ignition sources such as cigarettes and sparks from electrical equipment do not come into contact with combustible materials.

Question 8

When using flammable liquids:

- Use the minimum volume of liquid required.
- Liquid should be in a properly labelled container.
- Ideally, the container will be metal with a self-closing lid.
- Use a metal tray to catch spills, and have absorbent material available.
- Use the liquid away from heat and ignition sources.
- Ensure that the workspace is well ventilated.
- Return containers to safe storage after use.

Question 9

The beam will distort, possibly causing the collapse of any structure it is supporting. It will also conduct heat and increase the possibility of fire spread.

Question 10

Typical characteristics of a fire door:

- Rated to withstand fire for a minimum period of time.
- Fitted with a self-closing device.
- Fitted with an intumescent strip.
- Fitted with a cold smoke seal.
- Vision panel of fire-resistant glass.
- Clearly labelled.

Question 11

Manual systems alone can only raise an alarm over a limited area and for a limited time. There has to be some means for the person raising the alarm to make it general – by using the phone or public address system, or a manual/electric system.

Question 12

Smoke detectors (both ionising and optical) and heat detectors (both fixed temperature and rate of rise).

Question 13

- General understanding of how extinguishers operate.
- Importance of using the correct extinguisher for different classes of fire.
- Practise in the use of different extinguishers.
- When to and when not to tackle a fire.
- When to leave a fire that has not been extinguished.

Question 14

Starvation (removing the fuel), smothering (removing the oxygen), and cooling (removing the heat).

Question 15

(a) Water – Class A.
(b) Carbon-dioxide gas – Class B.
(c) Dry powder – Classes A, B, C and D.
(d) Foam – Class A (and some for Class B fires).

Question 16

To direct occupants to the means by which they can safely leave the premises.

Question 17

The escape route should be as straight as possible, direct to the assembly point, clear of obstruction, free of materials that could pose a fire hazard, and wide enough throughout (including at doorways and openings) to provide for the unrestricted flow of people.

Question 18

An assembly point should be a place of total safety (outside the building, in the open air, away from any further danger from the fire). A refuge or a place of relative safety is a fire-protected area that is not outside in the open air, away from any further fire danger.

Question 19

- Ensuring all occupants leave by the designated escape route.
- Searching all areas to ensure that the area is clear.
- Ensuring that fire escape routes are kept open and clear at all times.
- Ensuring all doors and windows are closed on leaving the area.
- Conducting the roll-call at the assembly area.
- Meeting the fire service on arrival and informing them of all relevant details.

Question 20

There should be a roll call to ensure that all people in the affected area are present.

Unit GC2 – Element 7: Chemical and Biological Health Hazards and Risk Control

Question 1

Solids, liquids, gases, vapours, mists, fumes and dusts (including fibres).

Question 2

Toxic, harmful, irritant, corrosive, carcinogenic.

Question 3

Acute means that the substance has short-term effects (usually occurring after a large over-exposure over a short duration of time).

Chronic means that the substance has long-term health effects (usually occurring after repeated low-level exposures over a long duration of time).

Question 4

Inhalation, ingestion, absorption through the skin and injection through the skin.

Question 5

The label on a preparation that is dangerous for supply generally gives the following information:

- The name of the substance/preparation.
- The hazardous components of the substance.
- Indication(s) of danger and the corresponding symbols/warning phrases.
- Some basic precautions to take.
- Name, address and telephone number of the supplier.

Question 6

Safety data sheets are intended to provide users with sufficient information about the hazards of the substance or preparation for them to take appropriate steps to ensure health and safety in the workplace in relation to all aspects of their use, including their transport and disposal.

Question 7

Stain detectors:

- Are only suitable for gases and vapours, not dusts.
- Can be inaccurate.
- Can only be used for grab-sampling and not for taking time-weighted measurements.
- Are fragile.
- Have a limited shelf life.
- May be used incorrectly.

(Only three were required.)

Question 8

Smoke tubes are used to test the effectiveness of ventilation or extraction systems and to provide general information about air movements in a work area.

Question 9

Occupational exposure limits (OELs) are maximum concentrations of airborne contaminants, normally measured across a particular reference period of time, to which employees may be exposed, usually by inhalation.

Question 10

The limitations of OELs include the following:

- They are designed only to control absorption into the body following inhalation.
- They take no account of individual sensitivity or susceptibility (especially in relation to allergic response).
- They do not take account of the synergistic effects of mixtures of substances.
- They may be invalidated by changes in environmental conditions, e.g. temperature, humidity or pressure.

(Only two were required.)

Question 11

(a) Substitution.
(b) Work process change.
(c) Reduced exposure time.
(d) Elimination.

Question 12

Local exhaust ventilation (LEV) is a control measure for dealing with contaminants generated from a point source. Dilution ventilation deals with contamination in the general atmosphere of a workplace area.

Question 13

Dead areas are areas in the workplace, which, owing to the airflow pattern produced by the positioning of extraction fans and the inlets for make-up air used in the ventilation system, remain motionless and so the air is not changed. They are a problem because non-moving air is not being mixed and diluted with fresh air, so high levels of hazardous substance can exist in these dead areas.

Question 14

The main types of respirator are filtering face-piece respirators, half-mask respirators, full-face respirators, and powered-visor respirators.

For breathing apparatus, the three main types are fresh-air hoses, compressed airlines and self-contained systems.

Question 15

When selecting a respirator, the key criteria to consider are the type of hazard (dust, gas, vapour, etc), the category of danger, contaminant concentration levels and wearer acceptability (compatibility with other items of PPE being worn, physical requirements, face shape etc.)

Question 16

The main purpose of health surveillance is to identify, at as early a stage as possible, any variations in the health of workers that may be related to working conditions.

Question 17

Carbon monoxide (CO) is an asphyxiant gas, i.e. when inhaled it reduces the oxygen available to the body. The presence of CO in air causes asphyxiation when the CO combines with haemoglobin to form carboxy-haemoglobin, a compound which prevents oxygen transport by the blood. This causes headache, drowsiness, unconsciousness and death at relatively low concentrations.

Question 18

- **Asbestosis** – asbestos fibres lodge deep in the lungs and cause scar-tissue formation. If enough of the lung is scarred then severe breathing difficulties occur. Can prove fatal. Increases risk of cancer.
- **Lung cancer** – asbestos fibres in the lung trigger the development of cancerous growths in the lung tissue. Usually fatal.
- **Mesothelioma** – asbestos fibres in the lung migrate through the lung tissue and into the cavities around the lung and trigger the development of cancerous growths in the lining tissue. Always fatal.
- **Diffuse pleural thickening** – thickening of the lining tissue of the lung (sometimes known as pleural plaques) that causes breathing difficulties. Not fatal.

(Only three were required.)

Question 19

The harmful effects of cement include:

- Irritation or corrosive burns to the eyes.
- Irritation of the respiratory tract.
- Irritant dermatitis on skin contact.
- Allergic dermatitis on repeated skin contact.
- Corrosive burns to the skin on prolonged contact (sometimes referred to as cementitious burns).

Question 20

- Any manual handling of the waste.
- Mechanical hazards arising from any handling equipment, such as trucks or compactors.
- Fire hazards associated with storing combustible materials, especially if stored outside and accessible to trespassers.
- Health hazards arising from the chemical nature of the waste, e.g. toxic substances.
- Hazards arising from the mixture of incompatible chemicals that might react together to form harmful products, or even cause fire.
- Biological hazards that might arise from disposal of organic waste, such as food waste and the pests (e.g. rats) that might be associated.

Unit GC2 – Element 8: Physical and Psychological Health Hazards and Risk Control

Question 1

This refers to a daily personal exposure to noise at a level of 85 dB(A) over the course of a working day (eight hours), or an equivalent exposure over a longer or shorter period. This represents the workplace exposure limit for noise (in the EU) at and above which action must be taken to reduce employee exposure.

Question 2

One limitation of ear defenders is that the seal between the ear and the protective device may be less than perfect because of long hair, spectacle frames and jewellery, incorrect fitting, or the wearing of helmets or face shields. They may also become uncomfortable during use and be removed. Defenders must be routinely inspected, cleaned and maintained, and require dedicated storage facilities.

Limitations of ear plugs are that they offer less noise reduction at high noise levels, they are more difficult to see and therefore enforce, and they can be a source of contamination into the ear if hygiene practices are poor. They need to be correctly sized to fit the individual, they may interfere with communication, and their effectiveness will decrease with use.

Question 3

Symptoms of HAVS include:

- Vibration white finger (VWF) – the blood supply to the fingers shuts down and the fingers turn white (blanching) and become numb. The blood supply returns after a time and the fingers become red and painful.
- Nerve damage – the nerves carrying sensory information from the fingers stop working properly resulting in a loss of pressure, heat/pain sensitivity and feeling.
- Muscle weakening – grip strength and manual dexterity reduce.
- Joint damage – abnormal bone growth can occur at the finger joints.

Question 4

(a) Radio frequency.
(b) Infra-red radiation.
(c) Ultra-violet and infra-red.
(d) Visible radiation.

Question 5

Visible radiation is particularly dangerous to the eyes if it is intense (from a laser). The retina (sensory cells) at the back of the eye is very sensitive to visible light. If very intense, visible light can cause burns to exposed skin tissue.

Question 6

- Demands – ensuring that there are sufficient resources available to do the work required and that priorities and deadlines are negotiated and reasonable.
- Control – encouraging workers to plan their work, and make decisions about how it is completed and how problems will be tackled.
- Support – providing positive feedback, and focusing on performance, not on personality.
- Relationships – clear standards of conduct and policies to tackle harassment and bullying.
- Role – clear work objectives, job descriptions and reporting responsibilities.
- Change – consultation and involvement of staff in determining processes.